A Guide to the Use of Mechanical Site Preparation Equipment in North Central British Columbia

by
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SECOND EDITION
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August 1987

Northern Silviculture Committee in cooperation with

ECONOMIC & REGIONAL DEVELOPMENT AGREEMENT

Canada

BC

This manuscript was produced at the direction of the Northern Silviculture Committee. Funds for publishing were provided through the shareable component of the Canada/British Columbia Forest Resource Development Agreement – a five year (1985-90) $300 million program cost-shared equally by the federal and provincial governments.

Canadian Cataloguing in Publication Data

Coates, D. (David)
A guide to the use of mechanical site preparation equipment in north central British Columbia

(FRDA report, ISSN 0835-1929 ; 002)

Co-published by B.C. Ministry of Forests and Lands.
On cover: Northern Silviculture Committee in cooperation with Canada/BC Economic & Regional Development Agreement.
Issued under Forest Resource Development Agreement.
ISBN 0-7718-8617-9

1. Forest machinery – British Columbia. 2. Forest site quality – British Columbia. I. Haeussler, S. (Sybille). II. MacKinnon, A. (Andrew), 1956- . III. Bedford, L. (Lorne). IV. Maxwell, J. (James), 1956- . V. Canadian Forestry Service. VI. British Columbia. Ministry of Forests and Lands. VII. Northern Silviculture Committee. VIII. Canada/BC Economic & Regional Development Agreement. IX. Forest Resource Development Agreement (Canada). X. Title. XI. Series.

SD388.C62 1988 634'.9'5 C88-092037-8

© 1988 Government of Canada
Province of British Columbia

This is a joint publication of the Canadian Forestry Service and the British Columbia Ministry of Forests and Lands, in cooperation with the Northern Silviculture Committee.

Produced and distributed by the Ministry of Forests and Lands, Research Branch.

For additional copies and/or further information about the Canada-British Columbia Forest Resource Development Agreement, contact:

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506 West Burnside Road
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The first edition of this guide was published in May, 1984 as a cooperative project between the Northern Silviculture Committee and the B.C. Ministry of Forests.

Mention of trade names or products does not constitute endorsement by the B.C. Ministry of Forests and Lands or the Northern Silviculture Committee.

ACKNOWLEDGEMENTS

The concept of a field guide for site preparation in north central British Columbia was originally developed by the Northern Silviculture Committee and the Interior Forest Improvement Board. The first edition of this guide was prepared by Dave Coates and Sybille Haeussler, Skeena Forestry Consultants, and was printed in May 1984.

Many people have been involved in the production of this guide. Those individuals involved with the first edition must be recognized again for their contributions: T. Goold and A. Randall, Cariboo Forest Region; B. Williams and J. Przeczek, Prince George Forest Region; J. Lloyd-Smith and G. Pinkerton, Prince Rupert Forest Region; D. Brewis, Silviculture Branch, Victoria; R.G. McMinn, Canadian Forestry Service, Victoria; and S. Lindeburgh, O. Steen, R. Coupé, L. Jang, C. DeLong, and A. McLeod of the Prince Rupert, Cariboo and Prince George Ecology Sections. In addition, seven reviewers provided valuable comments on drafts of this second edition: Hank Krawczyk (Chetwynd Forest Industries, Chetwynd), Wayne Thorp (Louisiana Pacific, Dawson Creek), Steve Knowles (Finlay Forest Industries, Mackenzie), Charles von Hahn (B.C. Forest Service, Vanderhoof), Ordell Steen (B.C. Forest Service, Williams Lake), and Allen Banner and Anne Macadam (B.C. Forest Service, Smithers).

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1 INTRODUCTION

In 1981, the Northern Silviculture Committee (NSC) decided to write a guide to site preparation for northern interior sites. The first edition of this guide was prepared by Dave Coates and Sybille Haeussler, Skeena Forestry Consultants, Smithers, B.C. This second edition is an updated version of the original publication. It incorporates the increased knowledge and experience available to silviculturists in north central British Columbia today, including new site preparation equipment and ecosystem-based prescriptions.

The guide addresses techniques of mechanical site preparation only; it does not consider other site preparation techniques such as prescribed burning or chemical treatments. In addition, because it is a field guide and not a silvicultural manual or textbook, there is no detailed discussion of the biological principles and objectives of scarification, or of operational techniques used in mechanical site preparation. The user of this guide should refer to other literature sources for background information.

The area referred to in the guide as "north central British Columbia" encompasses the Sub-Boreal Spruce (SBS), Interior Cedar - Hemlock (ICH), Engelmann Spruce - Subalpine Fir (ESSF), and Boreal White and Black Spruce (BWBS) biogeoclimatic zones in the Prince Rupert, Prince George, and Cariboo Forest Regions, as described by the Forest Service's ecological classification program. The guide covers the full range of forested ecosystems described in these four biogeoclimatic zones.

The objectives of the guide are:

1. to provide up-to-date information on mechanical site preparation equipment available in north central British Columbia;
2. to record and communicate the experiences of NSC members who have used this equipment; and
3. to use this information to assist field silviculturalists working in north central British Columbia to make better ecologically-based prescriptions for mechanical site preparation treatments.

The guide is divided into four major sections. Section 2 ("Equipment Description and User Assessment") describes 25 types of mechanical site preparation equipment currently in use or with potential for use in north central British Columbia (Appendix 1 provides a list of experienced contact individuals for each piece of equipment). Section 3 ("Equipment Comparison: Costs, Productivity, and Availability") contains information on 1987 prices, productivity rates, treatment costs, and availability of the equipment described in Section 2. Section 4 ("Choosing the Right Equipment for the Site") includes descriptions of various site preparation objectives and the machines suited to each, a reference table for determining the ability of each type of equipment to perform under different site conditions; and mechanical site preparation interpretations for treatment units in the SBS, ICH, ESSF, and BWBS biogeoclimatic zones. Section 5 ("Further Information Sources") provides a listing of other publications and research bodies which serve as sources of additional information beyond the scope of this guide.

A user of the guide can find out more about a particular piece of equipment by studying the relevant parts of Sections 2 and 3 carefully, then browsing through Section 4 for an indication of where that piece of equipment can be used. Alternatively, a user with a particular site or cutblock in mind can refer to Section 4 directly to help him narrow down the alternatives for effective mechanical treatment of that site. He can then consult Sections 2 and 3 for more details on specific pieces of equipment.

2 EQUIPMENT DESCRIPTION AND USER ASSESSMENT

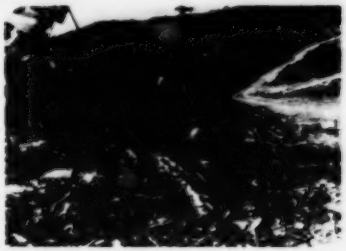
2.1 Patch Scarifiers

2.1.1 Leno scarifier: Model 77, Model 81

The Leno is a patch scarifier that attaches directly to the rear of the prime mover and is raised with the prime mover's winch for transport and mobility. It has two mattock wheels, each with four pairs of tines or paddles that scrape off surface organic matter to expose a patch of bare mineral soil as they turn. The Leno is unpowered; the screefed patch is prepared by the tines being dragged behind the prime mover. The release of the tines is controlled hydraulically. The patch length and distance between patches can be adjusted.

SUPPLIER:

Canadian Forestry Equipment Ltd.
17212-106th Ave.
Edmonton, Alta. T5S 1H9
Tel: (403) 484-6687
Telex: 037-3302



PHYSICAL SPECIFICATIONS:

Length:		
Working position		2.5 m
Transport position		1.0 m
Width:		2.5 m
Weight:	Leno 77	1400 kg
	Leno 81	1600 kg
Other: Distance between mattock wheel centres		1.8 m

ADDITIONAL/OPTIONAL EQUIPMENT:

- optional bucket-type teeth can be used to dig deeper where deep duff has to be penetrated
- chains are recommended for the rear tires of the skidder to improve traction and reduce tire wear
- a 2-way or slow release winch is recommended to allow the Leno to be gently lowered to the ground
- a V-plow mounted to the prime mover is recommended for medium to heavy slash conditions.

RECOMMENDED PRIME MOVER:

- skidders (85-100 kW for flat, light slash areas; 120-135 kW for areas with 30% + slopes or medium slash)
- D7 (D6, D8) or equivalent crawler tractor
- FMC for wet and/or steep sites

ATTACHMENT TO PRIME MOVER:

- the Leno comes with a mounting plate; the plate is generally welded (or can be bolted) to a skidder and the Leno is bolted to the plate
- it can be hooked (with modification) to the hitch of a crawler tractor
- the winch cable of the prime mover is hooked onto the Leno for lifting.

TRANSPORTATION:

- usually transported together with the prime mover on a lowbed
- hiab or flatdeck can be used for the Leno only
- a skidder can walk with the Leno raised.

MAINTENANCE AND REPAIRS:

- frequent adjustments to the hydraulic mechanism are required
- different weights of oil may be required, depending on the outside temperature
- must be greased daily
- oil change required every 100 hours.

AVAILABILITY OF PARTS:

- parts are generally available from the supplier in Edmonton
- some parts may have to be ordered from Montreal or Sweden.

METHOD OF OPERATION:

The Leno produces two rows of scalped patches 1.8 m apart. The patches are approximately 40 cm wide and average 10-15 cm in depth (depending on soil texture). The length of each patch (from 1 to 4 m) and the distance between patches are controlled by the timing of the hydraulic mechanism and the viscosity of the hydraulic fluid. Trees can be planted in the bottom of the screefed patch or on the side or in the loose mound of inverted material that forms behind each patch. Choice of planting spot will depend on site conditions. Screefed depressions are often the most obvious planting spot, but they may fill with water or be compact or nutrient-poor. The inverted mounds are frequently loose and may contain too much debris to be acceptable planting spots. On most sites, the best planting spot is probably intermediate between these two extremes: on the uphill side of the depression, at the base of the mound.

SITE PREPARATION OBJECTIVES:

The Leno is used to prepare screefed patches for planting. It prepares a superior planting spot to manual screefing and can improve initial growing conditions for the seedling. Planting and planting supervision are made easier, but the Leno alone cannot prepare defined planting trails. By leaving the majority of the site undisturbed, the Leno minimizes the potential for overscarification and erosion. The number of planting spots produced per hectare varies considerably, depending on site conditions and spacing objectives.

SUCCESS IN INFLUENCING SITE FACTORS:

Users have rated the Leno as good to excellent for:

- reducing grass competition
- reducing duff depth
- improving soil temperature.

Users have achieved variable results with the Leno for:

- reducing brush competition (scarified patches are too small to provide much relief from severe brush competition)
- reducing drought (reduces moisture competition from grass and other vegetation; patch acts as a small water catchment, but is not as effective as a deep trench)
- providing planting spots above a high water table (mounds are seldom sufficiently high or solid to make good planting spots).

MAJOR ADVANTAGES:

- high productivity
- low cost
- easy manoeuvrability
- ease of mounting on the prime mover.

MAJOR LIMITATIONS:

- in heavy slash areas, slash must be cleared by the prime mover for the Leno to be effective
- frequent adjustment is necessary to control patch length and spacing.

SITE LIMITATIONS AND OPPORTUNITIES:

The Leno works best on moderately wet to moderately dry sites with loamy soil textures, flat to rolling terrain (including slopes of up to 30-35%), and light to medium accumulations of fine slash. It is poorly suited to sites with shallow soils on rocky or broken terrain, with a high water table and thick organic soils (see Treatment Unit 6, Section 4.3), with duff layers greater than 25 cm or heavy clay soils, or with heavy slash.

MISCELLANEOUS CONSIDERATIONS:

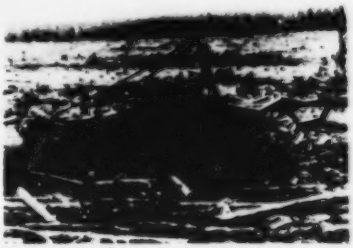
- Lowering the Leno roughly can cause extra stress on eyes, shackles, chain and rubber shock absorbers; to lower the Leno properly a 2-way winch should be used. The prime mover should be started slowly after the Leno is lowered.
- Hydraulic tines go out of adjustment during operation; the operator must make adjustments as necessary. Having the correct weight of hydraulic fluid for the outside temperature minimizes this problem.
- On heavy grass sites the sod can flip back, covering the scalped patch after treatment.
- The operator should carry a length of chain so that when he is stuck he can chain the Leno to the fairlead in an upright position, and so free the winch to help him get free.
- The Leno is not as rugged a machine as the Bracke, but much more manoeuvrable.
- Line skidders may be preferable to grapple skidders because the rear plate to which the Leno is attached is mounted perpendicular to the ground; on grapple skidders the rear plate is mounted at a 45 angle and this prevents the Leno from sitting in the proper operating position.
- Some users in the Cariboo have welded metal extensions to the tines to achieve better penetration of heavy clay soils on dry sites.

2.1.2 Bracke scarifier (2-Row Model)

The Bracke is a patch scarifier that attaches to the rear of the prime mover and rides on a set of large rubber tires. It has two mattock wheels, each with four pairs of tines, which are rotated by a chain drive actuated by the rubber wheels that support the machine. Because the mattock wheels turn more slowly than the ground wheels, each pair of tines is dragged through the ground for an interval before they rotate clear of the ground. The mattock wheels can be raised by attaching a chain to the two lift stays. Raising the mattock wheels facilitates transport and is essential for backing up.
The Bracke can be let out on the winch line of the prime mover and then winched back in to allow more mobility. This is very useful for negotiating short steep slopes. However, the Bracke cannot be lifted by the prime mover.

SUPPLIER:

KBM Forestry Consultants Inc.
360 Mooney St.
Thunder Bay, Ont. P7B 5R4
Tel: (807) 344-0811
Telex: 073-4603



PHYSICAL AND MECHANICAL SPECIFICATIONS:

Length:	5.0 m
Width:	2.5 m
Height:	2.0 m
Weight:	3000 kg

Other:
Distance between mattock wheels centres 2.0 m
Ground clearance 0.8 m
Drive chains (2): 4.4 cm
Four pairs of tines per mattock Tires: (2) 30 x 60 cm ; 16-ply

ADDITIONAL/OPTIONAL EQUIPMENT:

- mattock wheels with three or five pairs of tines
- 17-tooth (standard), 15- and 19-tooth intermediate axle gears
- replacement mattock teeth (on models since 1982)
- seeding units to seed scalped patches automatically
- larger models with three to five rows of mattock wheels (not tried in British Columbia)
- optional herbicide attachment

RECOMMENDED PRIME MOVER:

- skidder 110 kW +
- crawler tractor D6 (or equivalent) or larger.

ATTACHMENT TO PRIME MOVER:

- Bracke comes with a hitch which is usually welded to the prime mover
- hitch can be bolted to back plate of a skidder (requires drilling and tapping six 3/4-inch holes in the skidder back-plate)
- tow cable/chain of the Bracke is passed through the hitch and attached to the drum of the winch to allow the Bracke to be payed out and winched in.

TRANSPORTATION:

- hiab for the Bracke alone
- lowbed for Bracke and prime mover between blocks, with Bracke mattock wheels in raised position.

MAINTENANCE AND REPAIRS:

- correct size towing chain must be used; under-size chain wears through the towing bar tube at the point of intersection with the angle tube
- lift stays are often bent
- grease daily, and check oil in the four chain housings weekly
- drive chain links may break; keep spares handy.

AVAILABILITY OF PARTS:

- most parts can be obtained from the supplier in Thunder Bay
- parts ordered from Sweden take at least 2 weeks.

METHOD OF OPERATION:

The Bracke produces scarified patches that are about 2.5 m apart and roughly 60-80 cm long. The length of the scarified patch can be varied by changing the chain-driven gears or exchanging mattock wheels. Shifting the drive chain from 19- to 17- to 15-toothed gears results in progressively longer, less frequent patches; likewise, decreasing the number of paired tines per mattock wheel from five to four to three increases patch length and decreases the number of patches per hectare.

There is no method of adjusting the depth of the scalped patch, which is generally between 15 and 20 cm in depth. Slightly deeper patches are obtained when using heavier optional equipment such as the Bracke herbicider or when the Bracke mounder is used as a patch scarifier.

The Bracke produces planting spots similar to those produced by the Leno (see p. 4) and yields a good selection of microsites for planting. The inverted mound is often unsuitable for planting.

SITE PREPARATION OBJECTIVES:

The Bracke is used to prepare screefed patches for planting. It prepares a superior planting spot to manual screefing, and can improve conditions for initial seedling growth. Users report that the Bracke prepares between 1000 and 1500 planting spots per hectare. By creating only intermittent scalped patches, the Bracke minimizes the potential for over-scarification and erosion.

SUCCESS IN INFLUENCING SITE FACTORS:

Users have rated the Bracke as good to excellent for:

- reducing duff depth (up to 20 cm)
- reducing grass competition (lifts sod well)
- improving soil temperature

Users have achieved variable results with the Bracke scarifier for:

- reducing brush competition (scarified patches are too small to provide much relief from heavy brush; fine brush may spring back)

Users have rated the Bracke as fair to poor for:

- reducing slash.

MAJOR ADVANTAGES:

- a rugged machine, relatively maintenance-free
- can be let out on winch line and hauled back in

MAJOR LIMITATIONS:

- difficult to back up
- prime mover cannot lift the Bracke off the ground if it is in trouble.

SITE LIMITATIONS AND OPPORTUNITIES:

The Bracke scarifier performs best on flat to rolling sites with slopes up to 25%, light to medium slash, and loamy soils on mesic sites. It is poorly suited for working on very wet sites or sites with slopes steeper than 30%, heavy slash and/or high stumps, or duff layers greater than 25 cm.

MISCELLANEOUS CONSIDERATIONS:

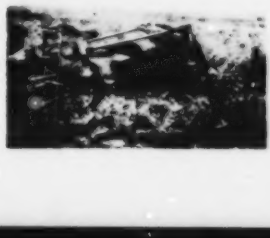
- On slopes over 20%, the Bracke has a tendency to overturn when contouring.
- The Bracke can be used together with a V-plow in medium to heavy slash.
- The Bracke does not work well on frozen soil.
- On wet sites the rubber tires often become mired.
- Do not work uphill on wet soils because the tires tend to slip, throwing off the patch length and distribution.
- Patch size and spacing cannot be altered as readily as with the Leno. However, once set, the gear mechanism maintains a regular spacing and does not self-adjust.
- The Bracke is a more rugged machine than the Leno, but less manoeuvrable and portable.

2.1.3 Bracke mounder

The Bracke mounder is a 2-row Bracke that has two hydraulically operated spades located behind the mattock wheels. The spades are actuated by the mattock wheel and dig into the scalp, depositing up to 20 L of soil on the upper slope of the scalp or on the inverted surface material.

The elevated mounds created by this machine have been shown to provide a better microsite for seedling survival and growth than the normal scalped patch or small mound of inverted material created by a patch scarifier.

The Bracke mounder has been used operationally in north central British Columbia since 1984. Approximately 3800 ha have been mounded during the 1984-1986 field seasons.



2.2 Disc Trenchers

2.2.1 TTS-35 and CFE disc trenchers

Disc trenchers are continuous row scarifiers that attach to the rear of a prime mover. The trenchers are adaptations of agricultural discs for forested sites. Both machines have two freely rotating (non-powered) spring-loaded discs, each with 10 rounded (CFE) or square (TTS) teeth. The discs are mounted at an angle on each side of a steel box frame. The disc angle of both machines can be adjusted to alter the width and depth of the furrow. Two different models are available for each machine.
For hydraulically powered disc trenchers see Section 2.9.1, p. 30.

SUPPLIERS:

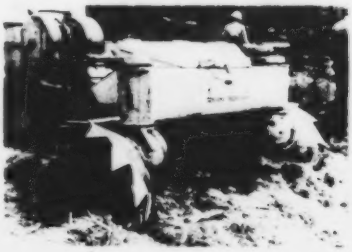
CFE disc trencher

Canadian Forestry Equipment Ltd.
17212 - 106th Ave.
Edmonton, Alta. T5S 1H9
Tel: (403)484-6687
Telex: 037-3302

TTS-35 disc trencher

KBM Forestry Consultants Inc.
360 Mooney St.,
Thunder Bay, Ont. P7B 5R7
Tel: (514)455-6101
Telex: 073-4603

Hakmet Ltd.
Box 248
Dorion, Que. J7V 7J5
Tel: (514) 455-6101



PHYSICAL SPECIFICATIONS:

	TTS (wide model)	CFE (larger model)
Length:	2.2 m	2.3 m
Width: (with discs)	3.55 m	2.44 m
Height:	1.5 m	1.2 m
Weight:	2025 kg	3175 kg

ADDITIONAL/OPTIONAL EQUIPMENT:

- a 10-mm Allen wrench is required to remove bearing cap screws on the TTS
- weight can be added to the steel box of the TTS for increased digging depth
- two TTS-35's have been modified to provide 3-m spacing between furrows.

RECOMMENDED PRIME MOVER:

- D6 type crawler tractor is minimum
- the 8220 Turex has been found to be a good prime mover for the TTS-35
- skidder with 120-150 kW.

ATTACHMENT TO PRIME MOVER:

- both machines come ready to be attached to the drawbar of a crawler tractor
- many users have found it better to attach the trencher to the winch cable.

TRANSPORTATION:

- lowbed for disc trencher and prime mover
- hiab for the trencher alone
- skidder can walk short distances with the trencher raised.

MAINTENANCE AND REPAIRS:

- welding and hard-surfacing of teeth are required
- grease once daily, more often in sandy soils, using a high quality grease.

AVAILABILITY OF PARTS:

- generally available from the suppliers; major parts may have to be ordered from overseas.

METHOD OF OPERATION:

These disc trenchers produce two parallel furrows or trenches, with the sidecast material forming two loose berms containing a mixture of slash, organic matter, and mineral soil. The furrows are continuous except when the machines ride over slash. The distance between furrows depends on the model of trencher, but is generally between 1.8 and 2.4 m, depending on the width of the discs. Furrows average 10-15 cm in depth and become shallow as the furrow is widened. Penetration into the soilcan be increased by adding weight to the steel box frame. Depending on local site conditions, trees can be planted at the bottom or sides of the furrow or on the berm.

SITE PREPARATION OBJECTIVES:

Disc trenches are used to prepare continuous trenches for planting. They prepare a superior planting spot to that produced by manual screefing, and can improve initial growing conditions for the seedling. They also provide excellent planting trails for planter access.

SUCCESS IN INFLUENCING SITE FACTORS:

Users have rated disc trenchers as good to excellent for:

- reducing grass competition
- reducing duff depth (up to 15-20 cm)
- improving soil temperature

Users have achieved variable results with disc trenchers for:

- incorporating mineral and organic layers
- reducing brush competition
- reducing drought
- providing planting spots above a high water table (best planting spots tend to be low on the berm or in the furrow rather than on top of the berm).

MAJOR ADVANTAGES:

- relatively high productivity and low cost
- produces well-defined planting trails
- provides a good choice of planting spots
- generally very versatile.

MAJOR LIMITATIONS:

- see "SITE LIMITATIONS", below.

SITE LIMITATIONS AND OPPORTUNITIES:

Disc trenchers work best on moderately wet to moderately dry sites with silt loam and coarser soil textures, and light to medium slash -- not enough slash to burn, but too much to plant untreated. Disc trenchers do not perform well on wet sites with duff depths greater than 20 cm or on sites with heavy slash and high stumps, rugged and broken terrain, or shallow, rocky or excessively stony soils.

MISCELLANEOUS CONSIDERATIONS:

- On sites where brush competition is expected, the trenches provide good access for future brushing and weeding projects.
- If increasing soil temperature is an objective of treatment, orient trenches so that they run north-south. This optimizes the solar angle, minimizing shading of seedlings and soil.
- Trenches are never truly continuous because the disc trencher rides up over slash. This reduces the potential risk of erosion if trenches are oriented up and down a slope.
- Disc trenchers can overturn on rough or steep ground.
- Damage and wear and tear to discs will occur on shallow, rocky, or stony soils.
- One NSC member has found that delaying treatment for one growing season after logging on winter-logged blocks significantly reduces the chances of getting stuck.

2.3 Brush Blades

2.3.1 Beales blade and Eden piling rake

A brush blade is a straight blade with curved teeth extending below the blade like a rake. The blade is mounted on the front of the prime mover. The Beales blade is the most common form of brush blade used in British Columbia. It has seven fixed teeth approximately 40 cm long.
The Eden rake has flexible teeth, controlled by hydraulic cylinders, which will bend back on contact with fixed objects. The hydraulic cylinders can be adjusted for pressure.
The CFE slash rake, a brush rake with spring-loaded retractable teeth, is noted in Section 2.9.5, on p. 31.

SUPPLIER:

Beales blade
Weldco - Beales
116 E. 2nd Ave
Vancouver, B.C. V5T 1B5
Tel: 873-4741

Eden piling rake
Cazes and Heppner Forest Services Ltd.
Postal Box 2037,
Clearbrook, B.C. V2T 3T8
Tel 853-0874

PHYSICAL SPECIFICATIONS:

Both blades come in three sizes.

	Width	Weight
Beales blade	3.22 m	1293 kg
	3.53 m	1746 kg
	3.76 m	1995 kg
Eden rake	2.44 m	907 kg
	3.05 m	1043 kg
	3.66 m	1179 kg
Flexible teeth (5):		46 cm

ADDITIONAL/OPTIONAL EQUIPMENT:

Eden rake
- requires hydraulic hose hook-up to charge cylinders.

RECOMMENDED PRIME MOVER:

Beales blade: Crawler tractor D6 or larger
Eden rake: Skidder with 90-150 kW (well suited to Cat 528 skidder) or crawler tractor D7 or larger.

ATTACHMENT TO PRIME MOVER:

- both blades are attached to the C-frame of the crawler tractor
- Eden rake can be mounted to the blade of a skidder or specially fitted directly to the skidder.

TRANSPORTATION:

- with the prime mover on a lowbed
- walked with a skidder.

MAINTENANCE AND REPAIRS:

Beales blade: Very little; occasional broken tooth
Eden rake: Hydraulic cylinders must be regularly primed for pressure. Daily greasing is required. Hydraulic cylinders can be damaged by slash.

AVAILABILITY OF PARTS:

- most parts are readily available locally
- special parts can be obtained from the supplier in Clearbrook.

METHOD OF OPERATION:

Brush blades are used primarily to align slash by windrowing, clearing planting lines, or piling and bunching. They are designed to move slash and brush without removing the excessive amounts of topsoil that are usually scraped away when a straight blade is used. The Eden rake, in particular, is designed to go over stumps, rather than uprooting them, to avoid excessive soil disturbance and to minimize the amount of soil that finds its way into slash piles. Brush blades are also used for pre- and post-logging scarification to expose mineral soil for natural regeneration, or to prepare planting trails. Brush blades may also be used to rip landings and other areas of compacted soil.

SITE PREPARATION OBJECTIVES:

Brush blades are used to prepare sites for planting or natural seeding. Planting access is improved by realignment of slash, and plantable spots are created by exposing mineral soil. Natural regeneration is promoted by mixing mineral and organic material and by distributing cone-bearing slash. Hazard abatement is also achieved by piling slash for burning or by simply flattening and redistributing slash.

SUCCESS IN INFLUENCING SITE FACTORS:

Users have rated brush blades as good to excellent for:

- reducing slash
- removing unwanted brush or tree species.

Users have achieved variable results with brush blades for:

- reducing duff depth (difficult to control amount removed)
- reducing brush competition (excessive mineral soil exposure may intensify brush competition; roots may be left intact)
- incorporating mineral and organic layers
- providing planting spots above a high water table (because it is difficult to create raised planting spots).

MAJOR ADVANTAGES:

Beales blade:

- readily available
- requires very little maintenance.

Eden rake:

- can do piling without uprooting stumps
- produces cleaner piles and less site degradation than a standard brush blade
- very mobile when attached to a skidder
- hydraulic cylinders which control the flexible teeth can be adjusted to meet site-specific requirements.

MAJOR LIMITATIONS:

Beales blade:

- major site degradation may occur if care is not taken
- use of this blade tends to be a slow (and therefore expensive) operation because it continually backs up.

Eden rake:

- not readily available
- skidder model is ineffective in areas where stumps are high and closely spaced.
- relatively difficult to mount
- when used with a skidder, the skidder may overheat.

SITE LIMITATIONS AND OPPORTUNITIES:

Beales blade/Eden rake (on crawler tractor)

These blades are most effective on medium to heavy slash areas which are not suitable for slashburning or drag scarification. Ideal sites are mesic to subhygric, where some removal of surface soil will not seriously reduce productivity. Slopes should be less than 25%. These rakes are not appropriate for dry sites with coarse-textured soils and thin humus layers, soils with compact, fine-textured surface layers, wet sites, sites with light slash, or slopes greater than 30%.

Eden rake (on skidder)

This combination is best suited to sites with slopes less than 15%, and light to medium slash of relatively long piece size and low stumps. It is inappropriate for sites with slopes greater than 20%, sites with heavy slash, or wet sites.

MISCELLANEOUS CONSIDERATIONS:

- The operator must be experienced and trained in the objectives of the treatment; inexperienced operators tend to over-scarify.
- In areas with thin duff layers, the teeth of the brush blade should be "floated" over the surface to avoid scalping and reducing site productivity.
- The tendency to scalp the soil is greatest on steep slopes.
- Planting trails prepared along the contour on sloping sites have considerable cut and fill which impedes downslope movement of water. Planting trails oriented up and down slopes become erosion channels and should be avoided.
- When the Eden rake is used on a skidder, a weight imbalance occurs. It is helpful to use a grapple skidder or skidder equipped with flotation tires. As well, it is essential that the skidder's cooling system be maintained to avoid overheating.

2.3.2 FMC with 4- or 6-way blade

The FMC is a flex-track forwarder with superior traction and lower ground pressure than the conventional crawler tractors.
Kootenay Tractor has developed 4- and 6-way hydraulically controlled blades that can fit on either an FMC or conventional crawler tractor. The 6-way blade can be moved up and down, tilted from side to side, and angled right and left. The 4-way blade is a smaller, lighter blade that cannot be angled. The tilting capacity of both blades is a valuable feature for contouring.

SUPPLIER:

Kootenay Tractor and Supply Ltd.
323 Vernon Street
Nelson, B.C. V1L 4E3
Tel: (604) 352-5301

PHYSICAL SPECIFICATIONS:

(Brush blade)

	4-way	6-way
Width	2.5 m	2.8 m
Height	1.2 m	1.2 m
Weight	816 kg	1360 kg
Other		
Tilt	18°	18°
Angle	n/a	30°

The 6-way blade creates a 2.4-m swath when angled at 30°.

ADDITIONAL/OPTIONAL EQUIPMENT:

- 6-way and 4-way straight blade.

RECOMMENDED PRIME MOVER:

- FMC 200 series log forwarder.
- a smaller FMC (the FT-180) is available but has not yet been tested for silviculture in British Columbia. In the 1987 field season, Champion Forest Products of Hinton, Alberta, used the FT-180 as the prime mover for a Bracke scarifier.

ATTACHMENT TO PRIME MOVER:

- comes mounted onto FMC.

TRANSPORTATION:

- lowbed.

MAINTENANCE AND REPAIRS:

- follow manufacturer's recommendations.

AVAILABILITY OF PARTS:

- can be obtained from the supplier in Nelson or from:
  P.G. Power Train Parts Ltd.
  9390 Rock Island Road,
  Prince George, B.C.
  Tel: 561-2303

METHOD OF OPERATION:

The FMC with 4- or 6-way blade can be used in much the same way as any brush blade for windrowing, piling, and bunching on sites that would not normally be accessible for a conventional crawler tractor.
In addition, the machine can be used to prepare planting trails that follow the contour on slopes up to 45%. The blade can be kept parallel to the ground surface at all times, thus producing little side cutting (which would intercept water moving down the slope) and allowing good control of the depth of scarification.
On extreme slopes, the dip and dive technique can be used. The tractor travels straight down, screefs for a short distance (2.5-6 m), and leaves an undisturbed patch between the screefs. Debris is left as a berm at the end of the screef to hold back run-off and allow it to penetrate into the soil. Preiocated trails are used for the return route.
The FMC has also been used on a level site to create mounded microsites for planting above a high water table, and to improve soil temperature.

SITE PREPARATION OBJECTIVES:

The FMC with 4- or 6-way blade is generally used to prepare planting spots and improve planter access on difficult (steep and/or wet) sites that have brushed-in heavily.

SUCCESS IN INFLUENCING SITE FACTORS:

A single respondent rated the machine as good to excellent for:

- removing unwanted brush
- reducing effects of brush competition
- reducing slash

MAJOR ADVANTAGES:

- because of the tilting capacity of the blade contour, scarifying on steep slopes is much better than with a conventional blade
- can work in areas where other machines cannot: steep and/or wet sites, and areas of high or large stumps

MAJOR LIMITATIONS:

- on a site where other tracked machines can operate (i.e.,on a site of less than 25% slope, no wet spots, low stumps) the FMC is at a disadvantage because of relatively high treatment cost
- limited availability of the prime mover and experienced operators

SITE LIMITATIONS AND OPPORTUNITIES:

This tool is best suited to typical north aspect, wet, steep blocks where burning was not possible and brush competition is high. It is less appropriate for easy ground and is poorly suited to extremely rocky areas.

MISCELLANEOUS CONSIDERATIONS:

- The angling feature of the 6-way blade is particularly useful for sidecasting material during the construction of planting trails.
- The FMC requires a well-trained operator.
- The FMC can be used for dip and dive scarification on slopes up to 65-70%.
- The brush blade is ineffective in frozen ground when soil disturbance, duff removal, and soil mixing are required.
- The FMC does not achieve as good production as a standard brush blade on easy ground.
- It may be necessary to add weight to the rear deck of the FMC to counterbalance the weight of the blade.

2.4 Plows

2.4.1 V-plows: Beales type, Muirs type, West Fraser type

V-plows or V-blades are large V-shaped blades mounted to the C-frame of a crawler tractor. The shape of the blade allows it to clear a path in front of the prime mover without continually backing up and piling.
A variety of versions of the basic V-blade have been developed by the Ministry of Forests and Lands and other users in north central British Columbia.

SUPPLIER:
In general, V-blades are locally manufactured to the user's specifications.

PHYSICAL SPECIFICATIONS:
These vary considerably among the various blades available. A Beales plow developed by the Ministry of Forests and Lands has the following dimensions:

Clearing Width:	2.9m
Weight:	2268 kg

ADDITIONAL/OPTIONAL EQUIPMENT:
- Beales plow requires modified nose fitting and side arms to fit on a TD20 tractor
- additional side wings or deflecting plates are often added to improve deflecting ability
- a splitting tooth is available to split stumps.

RECOMMENDED PRIME MOVER:
- D7 or TD20-type crawler tractor
- V-blades have also been fabricated for both D8 and D9 crawler tractors.

ATTACHMENT TO PRIME MOVER:
- attaches to the C-frame of the crawler tractor; the attachment is much simpler than for the C&H plow
- Muirs plow is designed to fit a TD20
- Beales plow is designed to fit a D7.

TRANSPORTATION:
- on a lowbed, together with the crawler tractor, or on a hiab.

MAINTENANCE AND REPAIRS:
- very little maintenance required
- some welding
- surface hardening will be required on the cutting edges.

AVAILABILITY OF PARTS:
- parts are manufactured locally, and are readily available.

METHOD OF OPERATION:
V-plows prepare sites for hand planting by removing slash and competing vegetation along planting trails. The trails prepared are normally oriented along the contour and are typically between 2.5 and 3 m wide. Humus and surface mineral soil can also be removed, creating a shallow, scalped trough. The degree to which mineral soil is exposed depends on the scarification objectives and site conditions. Most plows have some type of depth control, but accurate control of scarification depth requires considerable operator experience.

SITE PREPARATION OBJECTIVES:
V-plows are generally used to prepare planting trails in recently logged blocks or to rehabilitate older, brushed-in blocks. The planting trails prepared improve planter access and ease of planting, while at the same time providing a better microsite for initial seedling growth than would be provided in an untreated site.

SUCCESS IN INFLUENCING SITE FACTORS:

Users have rated the V-plows as good to excellent for:

- reducing duff depth
- reducing slash
- reducing grass competition
- improving soil temperature

Users have achieved variable results with V-plows for:

- reducing brush competition (usually the plows give good initial relief, but brushing-in is rapid and may be enhanced)
- incorporating mineral and organic materials
- providing planting spots above a high water table (the plow does not really prepare a raised planting spot).

MAJOR ADVANTAGES:

- produce a well-defined planting trail
- are effective in medium to heavy slash, stumps, and/or heavy brush
- provide more efficient removal of slash than a brush blade.

MAJOR LIMITATIONS:

- may be difficult to control scarification depth
- tall residuals or saplings fall back on previous trails
- see "SITE LIMITATIONS", below.

SITE LIMITATIONS AND OPPORTUNITIES:

V-plows perform best on even to rolling terrain (slopes less than 25%). Sites particularly suited to V-plow use are those with moderate to heavy slash that cannot be burned, and older, brushed-in blocks requiring rehabilitation. V-plow use is limited on sites with broken or rugged terrain (slopes greater than 30%), frequent high stumps, thin duff layers or shallow soils, or frequent whole tree residual slash; and on very wet sites.

MISCELLANEOUS CONSIDERATIONS:

- A V-plow must have an experienced operator to be effective.
- They are good machines for winter site preparation on wetter areas if the ground is frozen and the snow is not too deep.
- Visibility may be improved in the autumn when leaves have fallen off the vegetation.
- V-plows are much the same as a C&H plow, but lighter, more manoeuvrable, and easier to mount to the prime mover.
- Many modifications have been made to this machine by various people. For suggested improvements, contact the appropriate people listed in Appendix 1.

2.4.2 C&H plow

The C&H plow is a V-plow that mounts to the C-frame of a crawler tractor. Originally it was designed to be used with a mechanical planter and consisted of a dual V-plow with an outer and inner plow. The configuration was found to be unnecessarily cumbersome when used solely for site preparation and users made many modifications. The manufacturer now produces a modified model (SP 609) that has no inner plow or rolling drum. The SP 609 is shorter and more manoeuverable than the older version.

SUPPLIER:

Cazes and Heppner Forest Services Ltd
Box 2037
Clearbrook, B.C. V2T 3T8
Tel: 853-0674

PHYSICAL SPECIFICATIONS:

	Older model	*SP 609*
Length:	3.0 m	2.0 m
Width:	3.0 m	3.2 m
Weight:	3628 kg	3090 kg
Height:	2.0 m	1.9 m
Clearing width:	2.5 m	

ADDITIONAL/OPTIONAL EQUIPMENT:

- on older models additional deflecting plates are often added to improve the plow's ability to deflect debris
- replacement blades are available for the cutting edge of the side arms of the new model.

RECOMMENDED PRIME MOVER:

- D6 and D7 type crawler tractors.

ATTACHMENT TO PRIME MOVER:

- designed to fit the C-frame of D6, D7, TD20, D65 Kumatsu, or similar tractors; other makes can be used but modifications must be made
- the plow is connected at the midpoint of the C-frame with sandwich plates and four pins. Hinged sidearm connecting plates attach to side-attaching points of the C-frame
- shims must sometimes be added between the plow and C-frame to ensure a snug fit
- new plows use large bolts for clamping to the C-frame.

TRANSPORTATION:

- hiab for plow only
- lowbed when mounted on prime mover.

MAINTENANCE AND REPAIRS:

- welding frequently required
- surface hardening on cutting edges.

AVAILABILITY OF PARTS:

- parts are available from the manufacturer in Clearbrook.

METHOD OF OPERATION:

The C&H plow was designed to prepare a strip of mineral soil ahead of a planting machine. In British Columbia a modified version is generally used to prepare trails for hand planting. The plow clears a continuous slash-free strip. The amount of soil and humus disturbance can be controlled by adjusting the setting of the plow, but this depends to a great extent on operator experience and site conditions. The planting trails are oriented along the contour on slopes up to 15-20%. On steeper slopes the machine can no longer contour, but strips must be discontinuous and angled across the slope to avoid creating erosion channels.

SITE PREPARATION OBJECTIVES:

The C&H plow is generally used to prepare planting trails in recently logged blocks or to rehabilitate older, brushed-in blocks. The planting trails improve planter access and ease of planting, while at the same time providing a better microsite for initial seedling growth than would be provided by an untreated site.

SUCCESS IN INFLUENCING SITE FACTORS:

Users have rated the C&H plow as good to excellent for:

- reducing duff depth (up to 30 cm)
- reducing slash
- improving soil temperature.

Users have achieved variable results with the C&H plow for:

- reducing brush competition (usually gives good initial relief, but brushing-in is rapid and may be enhanced)
- reducing grass competition
- incorporating mineral and organic materials
- removing unwanted brush or tree species.

MAJOR ADVANTAGES:

- produces a well-defined planting trail
- effective in heavy slash
- higher productivity and cheaper than a brush blade on similar sites.

MAJOR LIMITATIONS:

- older plows are difficult to mount and require frequent modification and repairs
- large with limited manoeuvrability
- depth of scarification may be difficult to control
- idlers are stressed by excessive weight on front of prime mover.

SITE LIMITATIONS AND OPPORTUNITIES:

The C&H plow is best suited to sites with even to rolling terrain (slopes less than 25%). It is commonly used on blocks with deep duff and moderate to heavy slash that cannot be burned, and on old brushed-in rehabilitation blocks.

MISCELLANEOUS CONSIDERATIONS:

- The C&H plow must have an experienced operator to be effective.
- Because of the length of the plow, the blade tends to dig in or rise above the ground when the terrain is uneven.
- The operator's visibility can be poor, especially where brush is heavy; visibility may be improved in the fall when leaves have fallen off the vegetation.
- The C&H plow operates much the same as a Beales or Muirs plow, but is heavier and less manoeuvrable.
- A new mounting system has been developed by the manufacturer which greatly reduces the attachment problems.
- Many modifications have been made to the older models by various people. For suggested improvements contact the appropriate people listed in Appendix 1.

2.4.3 Marttini plow (Model KLM 240, Model AKLM 190 [new])

The Marttini plow is a large V-shaped trencher that is pulled behind the prime mover. It is connected to the prime mover by a high goose-neck arch. A hydraulic system is used to set the depth of plowing. On some older models this is done through pin settings. The model KLM 240 is used in Alberta and Ontario, but none are presently used in British Columbia. A new, larger model, the AKLM 190, is now available and will be tentatively introduced into eastern Canada early in 1988. The Marttini plow is produced in Finland.

SUPPLIER:

Marcan Equipment Ltd.
241 Cedar Ave.
Thunder Bay, Ont. P7B 4V4
Tel. (807) 767-4367

PHYSICAL SPECIFICATIONS:

	KLM 240	AKLM 190
Length:	5.4 m	7.0 m
Width:	2.55 m	2.50 m
Height:	2.5 m	4.1 m
Weight:	3200 kg	4500 kg

ADDITIONAL/OPTIONAL EQUIPMENT:

- prime mover requires rear hydraulic power take-offs
- power winch with 30 m + cable
- auxiliary wings with shock absorbers can be used to push plowed material further from the furrow.

RECOMMENDED PRIME MOVER:

- KLM 240 is designed to fit a D7 crawler tractor.

ATTACHMENT TO PRIME MOVER:

- standard attachment to a crawler tractor by a high arched goose-neck drawbar
- special adaptation may be required for D6 or D8 crawler tractors.

TRANSPORTATION:

- can be hydraulically lifted on its wheels and towed as a trailer
- can be towed behind truck using a fifth wheel
- lowbed for the tractor and plow.

MAINTENANCE AND REPAIRS:

- cutting edges should be hard-surfaced before use
- hydraulic hoses and pipes are not well protected and are occasionally damaged
- on-site packing of hydraulic cylinders and hoses is common
- daily greasing.

AVAILABILITY OF PARTS:

- parts are manufactured in Finland
- parts may be obtained through Marcan Equipment Ltd.
- Alberta Forest Service manufactures its own plow points (teeth).

METHOD OF OPERATION:

The KLM 240 was designed to provide drainage ditches and raised berms for planting on peatland. It digs a central furrow flanked on either side by a cleared shelf or planting bank. The depth of the furrow can be controlled using the hydraulic mechanism or by changing the pin settings. The cleared width is between 2.0 and 2.5 m and the depth can be varied from a V-shaped furrow 35 cm deep to a shallow screef that removes virtually no mineral soil.

SITE PREPARATION OBJECTIVES:

The Marttini plow is used in the boreal forests of Alberta to convert aspen-grass sites to conifers and to prepare wet spruce sites for planting. It has only been used on an experimental basis in British Columbia to treat a very wet site with heavy organic layers. Artificial drainage channels are created by the furrows on very wet sites.

SUCCESS IN INFLUENCING SITE FACTORS:

There is not much experience with this machine among NSC members. A limited number of users have rated the Marttini plow as good to excellent for:

- reducing grass competition
- reducing brush/aspen competition
- reducing duff depth (over 30 cm)

Users have achieved variable results for:

- preparing planting spots above a high water table (the planting banks created by the machine are often not high enough and the berms are too loose to be good planting spots).

MAJOR ADVANTAGES:

- a rugged machine with simple attachment
- one of the few machines available that can treat sites with a high water table and very thick organic matter.

MAJOR LIMITATIONS:

- possibly too small a machine to handle British Columbia's slash conditions, but the new AKLM 190 model may have solved this.
- in areas with large amounts of slash, considerable time is lost in raising and reversing the plow to clear the debris.
- flooding in plowed furrows is common.

SITE LIMITATIONS AND OPPORTUNITIES:

The Marttini plow is best suited to flat to even terrain with small stumps and light slash, and to seasonally wet sites with deep duff layers. It is best used on loamy textured soils where grass competition is heavy or aspen suckering is extensive, or on upland aspen conversion projects where the aspen has already been cleared. It is poorly suited to spruce-balsam sites with heavy slash and large, high stumps, and gullied or broken terrain (slopes greater than 20%), or to sites with shallow soils.

MISCELLANEOUS CONSIDERATIONS:

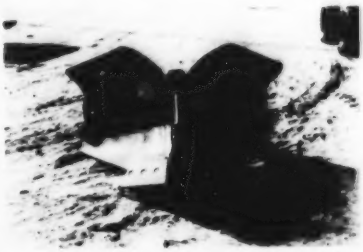
- The Marttini plow requires a skilled operator to obtain correct depth control.
- On heavy wet clay soils the plow often dives; some glazing also occurs in these soils.
- The plow should work along the contours at all times. Plowing up and down slopes greater than 15% can cause unacceptable erosion channels.
- This plow could be a useful machine for reforesting wetland areas, however, experience in British Columbia is too limited to know how it will adapt to provincial site conditions (which include heavy slash and large stumps on wet ecosystems).

2.4.4 Ripper plow

Ripper plows are basically a modification of the standard ripper tooth on the rear of a crawler tractor. The most common plow design is a double mouldboard type with replaceable cutting edges, which attaches to the ripper shank of the crawler tractor. The ripper tooth digs into the soil, while the plow attachment displaces the soil on either side. The plow must be on a hydraulic system so that it can be lifted clear of the ground when necessary.
Most users in north central British Columbia have developed their own version of the ripper plow, but a commercially produced model, the C-S reforestation plow, is available. This plow was redesigned in 1986 to minimize sloughing-in of sidecast material during spring thaw. The modified plow is larger and has extended wings.

SUPPLIER:

C-S reforestation plow
Canadian Forestry Equipment Ltd.
17212 - 106th Ave.
Edmonton, Alta. T5S 1H9
Tel: (403) 484-6687
Telex: 037-3302



PHYSICAL SPECIFICATIONS:

Each plow is custom-designed to fit the ripper shank of individual crawler tractors. Ripper teeth come in lengths of up to 90 cm.

ADDITIONAL/OPTIONAL EQUIPMENT:

- prime mover must be equipped with a ripper
- most users have widened the mouldboards for better side-casting
- heavy ice lugs may be needed for the crawler tractor

RECOMMENDED PRIME MOVER:

- crawler tractor D8 type or larger

ATTACHMENT TO PRIME MOVER:

- plow is mounted on any standard ripper tooth

TRANSPORTATION:

- together with the prime mover on a lowbed

MAINTENANCE AND REPAIRS:

- surface hardening is required on the cutting edges
- ripper tooth has to be replaced occasionally
- some welding

AVAILABILITY OF PARTS:

- available at most heavy duty equipment dealers

METHOD OF OPERATION:

This equipment has been designed specifically to treat difficult wet ground when it is frozen. The ripper tooth cuts into the frozen ground, while the plow attachment casts aside chunks of frozen soil to produce a furrow. The ripper tooth and plow can make a trench from 20 to 60 cm deep and roughly 1 m wide.

SITE PREPARATION OBJECTIVES:

The ripper plow is used to prepare planting spots and improve planter access on sites that are inaccessible except when frozen. It is one of the few scarification devices available that will rip a furrow in frozen ground. This equipment is primarily used in the boreal forest (BWBS) where many sites cannot be treated in summer.

SUCCESS IN INFLUENCING SITE FACTORS:

Users have rated the ripper plow as good to excellent for:

- reducing grass and brush competition
- improving soil temperature
- breaking up a dense root mat
- reducing duff depth (more than 30 cm)

Users have achieved variable results for:

- preparing planting spots above a high water table (planter selection is critical)
- incorporating mineral and organic matter

MAJOR ADVANTAGES:

- can prepare wet sites that other equipment cannot
- can rip trenches on frozen ground
- can scarify through deep duff layers
- provides a large selection of planting spots
- provides a method of treating muskeg areas effectively.

MAJOR LIMITATIONS:

- expensive
- snow depth may be too great before the ground is adequately frozen
- sidecast material may slough-in during spring thaw.

SITE LIMITATIONS AND OPPORTUNITIES:

The ripper plow is best suited to wet spruce sites with thick duff layers (greater than 20 cm), muskeg sites (with deep organic soils) that must be planted and cannot be burned, and clay soils with heavy grass and/or root mats in the Peace River area. It is not suited to use on broken or rugged terrain, steep slopes (greater than 25%), dry pine sites with thin duff layers, or unfrozen ground.

MISCELLANEOUS CONSIDERATIONS:

- The parallelogram frame on the C-S ripper plow allows the plow to follow the ground contours while staying at right angles to the surface.
- Operator training is essential because depth control and spacing of furrows are important for planting.
- The plow should never work at right angles to the slope, but always across the slope at gentle angles.
- On fine-textured soils or on steep slopes the plow should be lifted intermittently to reduce erosion.
- In heavy slash areas the prime mover rides on top of the slash and the plow tends to be out of the ground much of the time. A blade may be needed to windrow in front of the plow.
- This is an expensive treatment to be used only where severe site conditioning is required.

2.5 Drag Scarifiers

2.5.1 Anchor chain drag

Anchor chain drag scarifiers are large, specially constructed steel chains dragged behind a prime mover. The configuration of the scarification unit varies widely depending on the site conditions and scarification objectives. A series of large-link ship's anchor chains are attached parallel to one another to a straight or V-shaped drawbar or to a triangular skid boat. Large spikes (grouser bars) are welded spirally across the middle of the chain links. Shackles or clevises are used to hold the drag together. The chains are frequently used in combination with other drag scarification devices such as tractor pads or sharkfin barrels.

SUPPLIER:

Units are fabricated by users and local welding shops. Chains can be obtained from:
Capital Iron and Metals
1900 Store St.
Victoria, B.C. V8T 4R4
Tel: 385-9703

PHYSICAL SPECIFICATIONS:

Units are designed individually according to the user's specifications. Three basic chain weights are available:

Light:	8 kg per link
Medium:	14 kg per link
Heavy:	34 kg per link

ADDITIONAL/OPTIONAL EQUIPMENT:

- spare cables and shackle pins
- winch with 30 m of mainline
- hand come-along
- used crawler tractor rails and pads can be attached to the chains for extra ballast.

RECOMMENDED PRIME MOVER:

- crawler tractors D7 or larger (depends mainly on the total scarifier weight)
- skidders for light units on easy ground (TJ550, Clark 668).

ATTACHMENT TO PRIME MOVER:

- generally attached to the winch cable
- occasionally by chains to the hitch of the prime mover.

TRANSPORTATION:

- on a lowbed or flatdeck truck with hiab.

AVAILABILITY OF PARTS:

- most spare parts are readily available locally or in Prince George; see "SUPPLIER" above, for chains availability.

MAINTENANCE AND REPAIRS:

- some welding
- cable slings must be replaced after about 100 hours
- check and tighten all clevises or shackles daily.

METHOD OF OPERATION:

Anchor chains are used primarily to prepare sites for natural regeneration. The metal spikes remove humus, exposing a mineral soil seedbed. Some mixing of mineral and organic soil material takes place. Cone-bearing slash is distributed throughout the site and broken down so that it comes into closer contact with the soil. The weight of the scarification unit determines the depth and degree of soil disturbance. When wet soil is encountered, the winch line is let out, the prime mover moves forward, and it winches the chain through the soft area. For further information on drag scarification techniques, refer to the Ministry of Forests and Lands handbook "Drag Scarification in British Columbia".

SITE PREPARATION OBJECTIVES:

Anchor chain drags are used to prepare sites for natural regeneration (primarily lodgepole pine but also some spruce or Douglas-fir). Serotinous cones are distributed throughout the site and placed in contact with exposed mineral soil which stimulates cone opening and enhances survival of germinants. The scarification reduces fire hazard by simultaneously crushing and redistributing slash and promoting decomposition. Chain drags also destroy undesirable advance (balsam) regeneration. Occasionally they are used to prepare planting spots.

SUCCESS IN INFLUENCING SITE FACTORS:

Users have rated the anchor chain drag as good to excellent for:

- scattering cones and exposing mineral soil
- improving soil temperature.

Users have achieved variable results for:

- incorporating mineral and organic material (depends on volume of slash and duff depth)
- reducing duff depth (not effective over 10 cm).

Users have rated the anchor chain drag as fair to poor for:

- reducing slash
- reducing grass or brush competition.

MAJOR ADVANTAGES:

- easy to build and repair
- readily available
- relatively inexpensive treatment
- the number of chains can be changed and/or weights attached to match various conditions and levels of disturbance desired
- little chance of site degradation
- provides a good alternative to burning on sites where organic matter must be conserved.

MAJOR LIMITATIONS:

- difficult to transport between blocks, and time-consuming to assemble
- see "SITE LIMITATIONS", below.

SITE LIMITATIONS AND OPPORTUNITIES:

Anchor chain drag scarification is best suited to mesic and drier sites with even to rolling terrain (and little chance of brush invasion), low stumps and light slash, humus depths less than 10 cm, and cone-bearing lodgepole pine slash present. It is poorly suited to moist or wet soils with thick humus layers, slopes steeper than 25%, sites with heavy slash and high, large stumps, sites prone to rapid brush invasion, and spruce-balsam sites with no lodgepole pine seed.

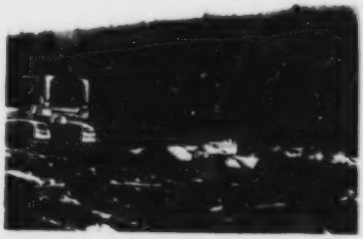
MISCELLANEOUS CONSIDERATIONS:

- As soil texture becomes coarser than a loam, decrease the number of chains (e.g., from five to three) to reduce soil exposure; on finer-textured soils, a greater number of chains are required to achieve the same degree of soil disturbance.
- Some NSC members have achieved their best production with wheeled skidders. However, care against overheating must be taken.
- Members have found that using the anchor chain drag to prepare planting spots is less cost-effective than using a patch scarifier.
- In general, anchor chain drags have not proven reliable for obtaining natural lodgepole pine regeneration in the Prince Rupert Region west of Burns Lake, where cones are apparently less serotinous than in other areas.

2.5.2 Sharkfin barrels

Sharkfin barrels are the heaviest scarification device attached to a chain drag. The large steel barrels have protruding fins arranged in a spiral pattern and are attached to the prime mover by a swivel. This results in a circular cutting action when the barrels are towed.
The configuration of the scarification unit varies widely, depending on site conditions and scarification objectives. The number of barrels used generally ranges from two to six. The barrels are attached to a delta V-bar or triangular skid boat that is in turn attached to the prime mover.

SUPPLIER:
Units are fabricated by users's and local welding shops.



PHYSICAL SPECIFICATIONS:
Units are constructed to the user's specifications. Dimensions vary considerably. Barrels typically weigh between 500 and 1000 kg each.

ADDITIONAL/OPTIONAL EQUIPMENT:
- anchor chains
- for added weight the barrels can be filled with water or diesel
- tractor pads can be attached behind the barrels
- spare pins, shackles, and winch cable
- can be used with a blade or V-plow in heavy slash.

RECOMMENDED PRIME MOVER:
- D8 or equivalent crawler tractor
- skidders (135 kW +) can be used for light units on easy ground.

ATTACHMENT TO PRIME MOVER:
- attached to the winch cable on the prime mover.

TRANSPORTATION:
- on a lowbed or a flatdeck truck with hiab.

MAINTENANCE AND REPAIRS:
- grease swivels; and expect to lose cotter pins
- make sure all shackles are tight; check for cracks in barrels and worn swivels
- check oil level in cones daily.

AVAILABILITY OF PARTS:
- readily available locally.

METHOD OF OPERATION:
Because sharkfin barrels are much larger and heavier than anchor chains, they are much more effective in cutting through slash and ripping up the surface soil and roots. The barrels push aside debris and gouge into the soil, producing a continuous furrow. The spiralling action of the barrel assists in ripping the soil and clears debris from the barrel. Depth of soil penetration can be adjusted by changing the weight of fluid in the drums or by changing the configuration of the drums within the scarification unit.
For further details refer to the Ministry of Forests and Lands handbook "Drag Scarification in British Columbia".

SITE PREPARATION OBJECTIVES:
Sharkfin barrels are used to distribute cones and expose mineral soil for natural seeding where the humus is too deep and the slash too heavy for anchor chains alone. They are also used to prepare planting trails to improve planter access and expose mineral soil planting spots. A secondary objective of the treatment is hazard abatement, achieved by crushing and distributing slash.

SUCCESS IN INFLUENCING SITE FACTORS:

Users have rated sharkfin barrels as good to excellent for:

- reducing duff depth (up to 20 cm)
- scattering cones and exposing mineral soil.

Users have achieved variable results with sharkfin barrels for:

- incorporating mineral and organic matter
- improving soil temperature.

Users have rated sharkfin barrels as fair to poor for:

- reducing grass and brush competition
- providing planting spots above a high water table (planting spots tend to be at the bottom of the furrow).

MAJOR ADVANTAGES:

- easy to devise different configurations for different conditions
- tough and reliable
- easy to fix
- little training of the operator is required.

MAJOR LIMITATIONS:

- requires long runs to be effectively used
- cannot be raised to make discontinuous furrows on slopes
- mobility is poor
- can be difficult to assemble.

SITE LIMITATIONS AND OPPORTUNITIES:

Sharkfin barrel scarification is best suited to relatively flat ground with light to medium slash, moderately deep duff layers (10-20 cm), and well-drained soil conditions. It is poorly suited to broken or steep terrain with heavy slash, poor dry sites with thin humus layers that must be conserved, sites with shallow soils or high stumps, and sites sensitive to erosion.

MISCELLANEOUS CONSIDERATIONS:

- Barrels tend to roll downhill when contouring is under way on slopes over 15%.
- Barrels can be used effectively in light snow.
- Some NSC members have found that newer scarification equipment (e.g., patch scarifiers and disc trenchers) provides better, more cost-effective results than sharkfin barrels on similar sites.

2.6 Choppers

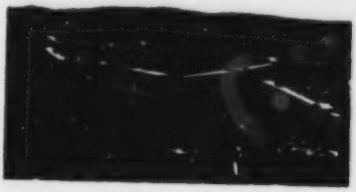
2.6.1 Marden chopper (Marden duplex brush cutter)

The Marden chopper consists of two large steel drums hitched in tandem and pulled behind a crawler tractor. Alternating high and low longitudinal blades are attached to the drums. The first drum is set at a 12° angle to the direction of travel and the second drum is at a 15° angle to that of the first drum. The drums can be filled with water or diesel to add further weight as necessary.

There are three models recommended for use on forested sites: the B-7GK, B-8GK, and B-10GK. The B-8GK is described below, with the other two being slightly smaller and larger models, respectively.

SUPPLIER:

Canadian Forestry Equipment Ltd.
17212-106th Ave.
Edmonton, Alta. T5S 1H9
Tel: (403) 484-6687
Telex: 037-3302



PHYSICAL SPECIFICATIONS (B-8GK):

No. of blades:	14
Drum length:	2.44 m
Drum diameter:	1.45 m
Overall length:	3.2 m
Weight (empty):	13438 kg
Capacity (both drums):	8327 L
Blade widths:	20/25 cm

ADDITIONAL/OPTIONAL EQUIPMENT:

- diesel is recommended as ballast
- a third drum can be added, or only a single one can be used (not recommended).

RECOMMENDED PRIME MOVER:

- D7, D8 or D9 type crawler tractor, depending on severity of conditions.

ATTACHMENT TO PRIME MOVER:

- hooks directly to the drawbar of a crawler tractor
- can also be hooked to the ripper attachment of a crawler tractor.

TRANSPORTATION:

- replace the spreader bar with a short coupling for transport. This allows the drums to run straight for easier loading.
- on a lowbed (with drums empty). Use a detachable neck lowbed if available.

MAINTENANCE AND REPAIRS:

- grease every 2-4 operating hours; Red Ram (or equivalent) recommended
- all moving parts should have grease fittings
- grease nipples are not well protected
- hardened fittings should be used for all clevis pins
- blades must be removed and sharpened frequently.

AVAILABILITY OF PARTS:

- parts are available locally or from the supplier in Edmonton.

METHOD OF OPERATION:

The Marden was designed to destroy unwanted and competing vegetation while simultaneously cultivating the soil. The blade on the front of the prime mover is used to push down vegetation and slash, which cut up by the drums. The combination of drum angle and alternating blade width creates a scraping, cutting, digging, and mixing action on the soil, vegetation, and slash as the drums move along. Some roots may also be cut up.

Vegetation and slash that is soft and flexible will tend to spring back after the Marden passes. The cutting action works best when the vegetation and slash are brittle, either very dry or frozen. When treatment is done on frozen ground, however, there is little soil disturbance, and mixing of soil and organic matter is not achieved.

SITE PREPARATION OBJECTIVES:

In British Columbia the Marden chopper is used mainly to destroy residual patches of mistletoe-infected lodgepole pine or to rehabilitate stagnant lodgepole pine, and to prepare these sites for planting or natural regeneration. It has also been used to treat areas of beetle-killed pine. The Marden promotes natural seeding and reduces fire hazard by redistributing slash and compressing slash and cones into contact with the soil. Although the Marden was designed to rehabilitate brushfields, attempts to reduce competition from deciduous species and grass in British Columbia have mostly been unsuccessful.

SUCCESS IN INFLUENCING SITE FACTORS:

Users rate the Marden chopper as good to excellent for:

- reducing slash
- removing unwanted trees.

Users rate the Marden chopper as fair to poor for:

- incorporating mineral soil and organic matter (only works when ground is unfrozen)
- reducing grass competition
- reducing brush competition (brush often springs back and sprouts back readily)
- producing planting spots above a high water table (does not create a raised planting spot)
- improving soil temperature.

MAJOR ADVANTAGES:

- can chop and distribute medium to heavy, small-diameter slash under the right conditions
- can effectively remove undesirable (small) trees
- is useful in conserving organic matter on dry/poor sites where burning or soil scalping is unacceptable
- causes little or no soil disturbance or erosion.

MAJOR LIMITATIONS:

- expensive to transport and operate
- requires much maintenance.
- maximum slope 20%
- not effective in areas of high stumps
- limited by wet, heavy snow (snow packs between blades on chopper).

SITE LIMITATIONS AND OPPORTUNITIES:

The Marden chopper is best suited to dry, flat, loamy or coarser-textured soil textures, light to medium slash and low stumps. Lodgepole pine or Douglas-fir sites, and temperatures below -10°C. It is poorly suited to gullied, broken, or rocky terrain with slopes greater than 20%, areas with frequent high stumps, or wet sites.

MISCELLANEOUS CONSIDERATIONS:

- It is critical that blades be kept sharp and the difference in blade width be maintained, or the success of the treatment will be greatly reduced.
- The best production in the Cariboo Forest Region has been with a D7 or D8 in second gear at 3/4 throttle.
- Best results for pine rehabilitation are achieved at temperatures below -10°C with no snow; dry powdered snow is less problematic than wet, heavy snow.
- The Marden does not work well on brushy spruce sites with soft ground, but can be used effectively on these sites if the ground is frozen. Chopping alone, however, is unlikely to be sufficient to control brush.

2.7 Agricultural Discs and Plows

2.7.1 Cultivating disc and agricultural breaking plow

A variety of agricultural equipment is covered in this section. The equipment consists of cultivating discs and agricultural plows that are towed behind a prime mover. The equipment is not modified for forestry use.

SUPPLIER:

There are several different types of equipment available from a variety of agricultural equipment suppliers.

PHYSICAL SPECIFICATIONS:

These vary. Most equipment is smaller and lighter than equipment designed specifically for forestry use.

RECOMMENDED PRIME MOVER:

- crawler tractor, D7 or larger

ATTACHMENT TO PRIME MOVER:

- either by a drawbar hitch, or to the winch line of the crawler tractor

TRANSPORTATION:

- hab
- agricultural breaking plow can be towed behind a 5-ton truck or 4 x 4 (for short distances) on its rubber tires.

MAINTENANCE AND REPAIRS:

- regular sharpening of cutting edges and normal lubrication
- general welding.

AVAILABILITY OF PARTS:

- usually available locally.

METHOD OF OPERATION:

Agricultural implements have been used primarily in the Peace River area for rehabilitation and conversion of aspen/willow sites. The discs and plows are used as a secondary treatment following landclearing by burning or piling slash, or on old sites requiring rehabilitation. The equipment is used to mix organic and mineral soil layers or to invert the sod layer. A system of "double discing" has been adopted in northern Alberta. With this, the area is disced in the standard manner early in the field season. Later, after vegetative regrowth, the area is redisced perpendicular to the initial discing. Double discing is used to increase soil/organic mixing and to decrease vegetative regrowth.

SITE PREPARATION OBJECTIVES:

This equipment has been used to prepare aspen and brush sites that have already been cleared for planting. The objectives of the plowing and discing treatment are to mix humus layers to increase fertility and improve soil temperature, to break up or invert grass sod, to cut up roots of aspen and other deciduous species to prevent suckering and sprouting, and to improve ease of planting in hard soils.

SUCCESS IN INFLUENCING SITE FACTORS:

Users have rated this equipment as good to excellent for:

- reducing grass competition
- reducing duff depth
- reducing brush competition
- improving soil temperature
- incorporating mineral and organic layers
- providing good planting spots above a high water table (agricultural breaking plow).

Users have achieved variable results for:

- removing unwanted brush and tree species (sites should be cleared first).

MAJOR ADVANTAGES:

- provides good mixing of surface soil layers and/or inversion of sod layers
- thorough treatment gives good control of aspen suckering.

MAJOR LIMITATIONS:

- see 'SITE LIMITATIONS', below

SITE LIMITATIONS AND OPPORTUNITIES:

Agricultural discs and plows operate best on even to gently rolling terrain that has been previously piled and/or burned so that area is free of slash and stumps. Stumps must either be old (10 years +) or removed before treatment. This equipment is unsuited for working on sites with medium to heavy slash, many stumps, rocky and/or stony soils, or slopes greater than 15%.

MISCELLANEOUS CONSIDERATIONS:

- When plows turn up clay heavy soils, some hardening can take place and make planting difficult.
- These treatments are relatively inexpensive by themselves; however, they are usually done on sites that have previously been cleared at considerable expense.
- These treatments are one of the few mechanical means available to treat very heavy grass sod or severe aspen competition effectively.

2.8 CAT 205 LC EXCAVATOR

DESCRIPTION:

The Cat 205, with a Perkins engine flywheel power rating of 53 kw (71 HP), is the smallest excavator made by Caterpiller.
The excavator has a standard track width of 600 mm and is equipped with a track-type undercarriage with lifetime lubricated rollers and idlers. Manoeuvrability is increased by hydrostatic drive with independent track motors capable of counter rotating the tracks.
For site preparation, a rake (or bucket) is attached to the 'stick' of the excavator.
Attachments are generally fabricated by owner operators and vary in design.

SUPPLIER:

Finning Tractor & Equipment Co. Ltd.
555 Great Northern Way
Vancouver, B.C. V5T 1E2
Tel: 872-4444
(Excavators can also be purchased through local branches or depots)

PHYSICAL SPECIFICATIONS:

Width:	2.5 m
Height:	3.0 m
Weight:	13 000 kg
Ground Pressure:	33.00 k Pa

(Specifications based on 600 mm width shoe one-piece boom, medium stick and bucket.)

ADDITIONAL/OPTIONAL EQUIPMENT:

For Cat 205 LC:

- long undercarriage for lower ground pressure and increased stability
- several track widths with different ground pressure: 500 mm (39 K Pa), 750 mm (27 K Pa), 900 mm (23 K Pa).

For Attachments:

- sharp tines can be welded perpendicular to the back of the rake (for slash dispersal).

TRANSPORTATION:

- lowbed

AVAILABILITY OF PARTS:

- parts can be obtained from local Finning outlets.

ATTACHMENT TO PRIME MOVER:

- rake (bucket) mounted directly on excavator stick.

EXCAVATORS PRESENTLY USED IN NORTH CENTRAL BRITISH COLUMBIA

- Cat 205 and 215, John Deere 490 and 690B.

MAINTENANCE AND REPAIRS:

- Follow manufacturer's recommendations.

METHOD OF OPERATION:

Excavators can be used for patch scarification, rough mixing, or mounding. When patch scarification is required, the rake is used to remove surface slash and debris before a bare mineral patch is created. Rough mixing is accomplished by placing the rake in the slash and organic material, pushing it away from the excavator to clear the slash and loose organic material, then pulling it toward the excavator to mix the soil. Mounds can be constructed either by depositing mineral soil directly onto the undisturbed forest floor, or by folding back the humus, tamping it with the bottom of the bucket (or rake), then depositing fine organic material or mineral soil on top of the previously inverted humus. Mound form, patch size, and degree of mixing can be varied to meet site specific requirements.

SITE PREPARATION OBJECTIVES:

- to increase the number of acceptable planting spots.
- to optimize soil moisture and temperature conditions and nutrient availability.

Screefing: reduces duff depth and initial brush competition. In well-drained soils with deep duff layers, it will increase growing season rooting-zone temperatures. Patch scarification minimizes the danger of over-scarification and soil erosion.

Mixing: on sites with 10 cm or more of duff, intermixture of duff layer with mineral soil may improve soil temperatures and moisture and nutrient availability.

Mounding: improves growing season rooting-zone temperatures and aeration on wet or cold sites and may improve nutrient availability.

MAJOR ADVANTAGES:

- versatile; treatment can be matched to site on a heterogenous unit
- easy to manoeuvre, works well in areas of high or large stumps
- works well on wet ground and/or areas with thick humus
- can work on slopes up to 45%
- readily available.

MAJOR LIMITATIONS:

- on areas where other site preparation equipment can operate the Cat 205 is at a disadvantage because of its relatively low productivity and high treatment cost. This is particularly true in heavy slash or on steep slopes.
- limited availability of operators with silvicultural experience

SUCCESS IN INFLUENCING SITE FACTORS:

Good to excellent for:

- reducing duff depth
- improving soil temperature
- providing planting spots above a high water table

Variable results for:

- incorporating mineral and organic layers
- reducing brush competition (brush reduction is a function of: patch size, vegetation type, mineral soil exposure, mound size, capping material, etc.)

Fair to poor for:

- reducing slash

SITES CONDITIONS BEST SUITED FOR:

- submesic to hygric sites
- sites not well suited to conventional site preparation equipment

Sites conditions not suited for:

- easy ground
- areas requiring slash abatement
- patch scarification is not recommended on sites with a high water table
- mounding is not recommended where soils are extremely sandy, gravelly or heavy clay in texture.

MISCELLANEOUS CONSIDERATIONS:

- Excavators with wide pads, working in severe "underfoot" conditions, may experience undercarriage problems.
- Planter access must be considered when treating areas with heavy slash or dense brush. On such sites, patch scarification may result in dense interpatch accumulations which severely limit planter mobility.
- As slash loading increases, the ability of the excavator to function on slopes decreases. Therefore an excavator should not be used on steep slopes with heavy slash.
- The Cat 205 has been used for terracing on slopes up to 45%. (The treatment is costly and is not recommended for sites prone to erosion).
- Large holes are often created adjacent to mounds.
- The rate of revegetation increases as the percent of organic material in the mound "cap" increases, i.e., organic mounds are more prone to revegetation than mineral mounds. Moisture stress can be a problem in mounds capped with coarse-textured mineral soil (sandy loam or coarser, or with a high gravel content) or material that is very fine in texture (clay to heavy clay). While the capping material should be at least 8-10 cm in depth, the total elevation of the mound should be minimized to conserve moisture.

2.9 Other Equipment

There are many types of mechanical site preparation equipment available. This guide has covered only the equipment most commonly used in north central British Columbia. The Forest Engineering Institute of Canada (FERIC), through its equipment directory (see details under Section 5, "Further Information Sources"), can provide an extensive list of equipment used worldwide. The U.S. Department of Agriculture and private industry in the United States are developing and testing many new pieces of equipment which may eventually be of potential use in north central British Columbia.
Below are short descriptions of several pieces of equipment that either are currently in use or have potential use in British Columbia.

2.9.1 Hydraulically powered disc trenchers (TTS Delta, TTS-35 HJ, Donaren, Wadell)

The trenchers listed above are available with hydraulic down pressure alone or hydraulic down pressure combined with powered (driven) discs. The machines were brought into use in Sweden and Finland when foresters there began limbing trees on site and had to get through piles of slash on their scarification projects. Houston Forest Products (Tel. 845-2322) has been using the TTS Delta (hydraulic down pressure/non-powered discs) since 1984. Reports on this trencher are available from Houston Forest Products and FERIC. Arboress Enterprises Ltd. (Tel. 564-3629) used the Donaren 1800 disc trencher (hydraulic down pressure/powered discs) in north central British Columbia during 1986 and will be operating the new Donaren 280 in 1987. The Donaren 280 can be set to produce intermittent furrows. Westar Timber, Vanderhoof (Tel. 567-4725), used the TTS Delta (hydraulic down pressure/powered discs) and Wadell scarifier (hydraulic down pressure/powered cones) during 1987. The Wadell scarifier prepares the soil with a pair of toothed cones which turn against the direction of the prime mover.

2.9.2 Sanders-Araki deep tilling plow

This machine is built by a firm in Merritt, B.C., and is similar in function to a ripper-plow. The Sanders-Araki has two ripper teeth and thus produces two furrows in one pass. The machine is being used to improve soil moisture conditions and reduce grass competition on dry, fine-textured soils in the Kamloops Forest Region. For further details, contact Lorne Bedford, Silviculture Branch, Victoria (Tel: 387-8909).

2.9.3 Winged subsoiler

A winged subsoiler was tested in north central British Columbia during 1985. The Subsoiler, developed for ripping compacted soils, is comprised of three curved shanks vertically mounted on a main, horizontal machine frame bar. "Flighted shoes", available in a number of designs, are affixed to the lower tip of each shank and may be rapidly exchanged to accommodate a variety of soil conditions. A variable-pressure, hydraulic release mechanism on each shank allows shanks to trip independently when they encounter large underground obstructions, and then to return to the operating position. The machine frame is connected to a fabricated two-point hitch on the prime mover, and activating the tractor winch line allows the subsoiler to pivot upward, clear of the ground, for transport or to clear debris. When compared to a standard rock ripper on compacted landings, the winged subsoiler provided superior profile shatter (137% versus 26%, respectively). For further details, contact Mike Bruhm or Angus McLeod, Prince George Regional Office (Tel: 565-6100).

2.9.4 Madge rotary landbreaker (Rotoclear)

The landbreaker is a self-powered machine pulled behind the prime mover. It was designed for total land clearing and operates by chopping up surface material and mulching it into the mineral soil. Large debris must be moved aside by the prime mover. The mixing action provided by this machine may be preferable to scalping on sites where humus and surface soil layers should be conserved. It should create excellent planting sites when used under the correct conditions. On brushy sites the chopping action may control brush regrowth. For further details, contact Brian Wesleyson, Fort St. John Forest District, Prince George Forest Region, Fort St. John (Tel: 787-3326).

2.9.5 CFE slash rake

The CFE slash rake is manufactured by Canadian Forestry Equipment in Edmonton. It is similiar in design to the German-made Raumfix slash rake. Different models of the CFE slash rakes equipped with 4, 5, 6 and 7 teeth are available for mounting on rubber-tired skidders. The rake has spring-loaded teeth which are designed to move up and down on tracking guides when an immovable obstacle is encountered. This feature prevents uprooting of stumps, reducing ground disturbance and minimizing the amount of soil in windrows and piles. A 4-tooth CFE slash rake mounted on a Timberjack 450 skidder was used experimentally near Vanderhoof in the fall of 1986. For further information, contact Charles von Hahn, Vanderhoof Forest District, Prince George Forest Region. (Tel: 567-6363).

2.9.6 Sinkkila HMF scarifier

The Sinkkila HMF scarifier, manufactured in Finland, was field tested in the Prince George Forest Region in 1986. It consists of two large scarifying wheels, each with four pairs of rippers 80 cm in length. Intermittent scalps or continuous furrows or mounds can be produced by altering the ripper angle and hydraulic braking applied to it.
Overheating problems in the Sinkkila's hydraulic braking system resulted in poor overall machine availability and performance. The lessor, Forest Lease Inc., is presently modifying the Sinkkila in an attempt to solve the overheating problem.
A detailed study on the Sinkkila was undertaken by FERIC. Results from this study will be available as FRDA Report No. 006.

2.9.7 Eden relief bedding plow

The Eden relief bedding plow is manufactured by Cazes and Heppner Forest Services Limited in Clearbrook. The bedding plow consists of six large hydraulically controlled discs which are arranged three to a side, offset and concave inward. Each disc is attached to a swing arm which functions independently, allowing a single disc to climb over obstacles up to 38 cm in height. The bedding plow creates a raised bed of mixed mineral and organic material which is approximately 2.7 m wide. For further information, contact Delee Anderson, Vanderhoof Forest District, Prince George Forest Region (Tel: 567-6363).

2.9.8 Ministry ripper mounder

The Ministry of Forests and Lands has developed a prototype D7 ripper mounder. The digging blades of the mounder, mounted on the ripper parallelogram, are hydraulically activated and electronically controlled. The digging cycle involves forcing the digging blades into the ground to a controlled depth, raising the blades after a predetermined period, and flipping the blades to invert the mound. The digging cycle is computer controlled and can be changed to create appropriate mounds for different sites.
The mounder prototype was field tested in 1985 and 1986. A pre-production D8 mounder was in operational use in 1987. For further information, contact Lorne Bedford, Silviculture Branch, Victoria (Tel: 387-8909).

2.9.9 Downing chain

Approximately 55 m of heavy chain is pulled between two D8 or D9 size crawler tractors to knock down standing (usually dead) timber. It may be necessary to use a rolling or dragged ball fitted at the centre of the chain to keep the chain at ground level. This method has been used successfully to rehabilitate burned-over areas in the Prince Rupert and Prince George Forest Regions. For further information, contact the Regional Silviculture Section.

2.9.10 Hawk power scalper

The Hawk power scalper is a hand-held scarifier built and marketed by Bruce Hawkenson of Prince George (Tel: 563-0727). The scalper consists of four double torsion springs mounted on a specially designed hub. The hub, driven by an Echo chain saw, rotates up to 5000 RPM. The scalper is used for screefing on blocks where terrain or access limit treatment by more conventional equipment. A short report, FERIC Field Note: Silviculture #5, describes the scalper in more detail.

2.9.11 Rader Canada

This equipment dealership now operates in Vancouver, offering a line of site preparation equipment for forestry. Most of the equipment supplied is similar to products described elsewhere in this guide. No Rader equipment is currently in use in north central British Columbia.

Address:
Rader Canada Ltd., Pacific Division
Box 65567, Station F
Vancouver, B.C. V5N 5K5
Tel: (604) 299-0241
Telex: 043-54570

3 EQUIPMENT COMPARISON: COSTS, PRODUCTIVITY, AND AVAILABILITY

Table 1 presents, for each piece of equipment in the guide, current purchase price and representative productivity rates and costs per hectare for sites in north central British Columbia. The equipment price was obtained from the supplier. Productivity rates are the result of controlled time studies (Maxwell 1987). Treatment costs were provided by members of the Northern Silviculture Committee. Cost figures are estimates and should be used as a rough guide only.

TABLE 1. 1987 equipment costs and typical production rates in north central British Columbia

Equipment name	1987 Price[a] ($)	Productivity[b] (ha/hr)		Treatment cost ($/ha)	
TTS-35 disc trencher	28 500	Range	1.03-1.60	Average Range	115 100-125
CFE disc trencher(B-1)	36 900	Range	1.03-1.60	Average Range	115 100-125
TTS Delta (hydraulic down pressure)	49 000	Range	1.36-1.60		
TTS Delta (with powered discs)	62 000	Range	Not Available		
Donaren 180D	60 000	Range	1.58-2.57	Average Range	140 110-160
Leno scarifier	53 000	Range	0.57-1.38	Average Range	110 85-130
Bracke scarifier (2-row)	38 950	Range	0.54-1.39	Average Range	115 90-155
Bracke mounder	77 500	Range	0.55-1.25	Average Range	230 155-265
V-plow	14 000 (est)	Range	0.46-1.08	Average Range	210 190-250
C&H plow (SP609)	16 900[c]	Range	0.46-1.08	Average Range	210 190-250
C&S reforestation plow (ripper plow)	6 200	Range	0.57-0.86	Average Range	260 225-300
Eden rake 3m skidder model	13 800[c]	Range	0.23-0.61	Average Range	175 140-220
CFE slash rake #4	13 900	Range	0.40	Insufficient data	
Brush blade	Variable	Range	0.21-0.37	Average Range	280 200-450
FMC prime mover (≥20)	252 000				
FMC six-way blade	16 500	Range	0.30-0.76	Average Range	400 280-750
Four-way blade	14 000	Range	Not available		

TABLE 1. (Continued)

Equipment name	1987 Price[a] ($)	Productivity[b] (ha/hr)		Treatment cost ($/ha)	
Anchor chain drag (4 sections, medium weight)	7 350[d]	Range	0.64-1.66	Average Range	125 80-175
Sharkfin barrels three barrels)	16 500[d]	Range	0.58-1.69	Average Range	125 100-200
Marden chopper (B86K)	65 000	Average	0.61	Average Range	225 180-250
Marttini plow (Model KLM 240)	Unknown	On a difficult site near Prince George the machine averaged 0.65 ha/hr. In 1986, average costs for aspen conversion on windrowed sites in Alberta were approximately $100.00/ha			
(Model AKLM-190)	88 000				
Sinkkila HMF scarifier	66 000	Average (Based on machine availability of 40% on windrowed site)	0.69		
Cat 205 excavator	81 000	Range	0.22 - 0.35[e]	Average Range	450 350-600
Cat 215 excavator	117 900	Not available			

[a] F.O.B. Prince George, excluding sales tax.

[b] The productivity values are given in scheduled operating hours. Production values above cannot be directly compared between implements because of differences in prime movers and site condition, eg. Powered trenchers are often used on more difficult sites than passive trenchers. Refer to the 1987 report "Silvicultural Site Preparation Equipment Productivity Study" by J.A. Maxwell (Silviculture File No. 955-4-1-2) for breakdown of productivity values by prime mover and site characteristics.

[c] F.O.B. Abbotsford, excluding sales tax.

[d] Prices estimated from costs between December 1, 1984, and April 1, 1987, at 3% per annum for the Interior.

[e] Based on coastal data for patch scarification (productivity from FERIC TN-93). At this time, there are insufficient data to establish productivity and cost estimates for mounding in north central British Columbia.

Most of the equipment described in this guide can be leased or rented from the supplier. Generally the rental or lease arrangements must be for a minimum of 3 months. The Marttini plow is not readily available. Equipment such as brush blades and some V-plows are often owner-operated by independent small contractors. Table 2 includes a number of V-plow "styles" rather than an exhaustive list of available V-plows.

TABLE 2. 1987 availability of equipment in north central British Columbia

Equipment name	Number of units owned	Owner
TTS disc trencher	1	Crestbrook Forest Industries, Cranbrook
	2	Fraser Lake Sawmills, Fraser Lake
TTS Delta disc trencher (hydraulic down pressure)	1	Houston Forest Products, Houston
TTS Delta disc trencher (powered discs)	1	Arboress Enterprises Ltd., Prince George
	1	Westar Timber, Vanderhoof (lessee)
	1	Chetwynd Forest Industries, Chetwynd (lessee)
CFE (M&M) disc trencher	1	Ministry of Forests & Lands, Kamloops
	1	Ministry of Forests & Lands, Prince George
	1	Ministry of Forests & Lands, Smithers
(hydraulic down pressure)	1	Tim Brown, Vanderhoof
Donaren 180D disc trencher (powered discs)	1	Arboress Enterprises Ltd., Prince George (lessee)
	1	Chetwynd Forest Industries, Chetwynd (lessee)
Donaren 260 disc trencher (powered discs)	1	Arboress Enterprises Ltd., Prince George
Wadell powered scarifier	1	Westar Timber, Vanderhoof (lessee)
Leno scarifier	1	Babine Forest Products, Burns Lake
	1	Ministry of Forests & Lands, Cariboo
	2	Ministry of Forests & Lands, Kamloops
	2	Ministry of Forests & Lands, Smithers
	3	Ministry of Forests & Lands, Prince George
Bracke scarifier (2-row)	1	Ministry of Forests & Lands, Kamloops
	1	Ministry of Forests & Lands, Nelson
	2	Integrated Silviculture Services, Prince George (lessee)
Bracke mounder	1	Integrated Silviculture Services, Prince George
	1	Lane Gellings, Fort St. John
V-plows		
-Muirs type	1	Ministry of Forests & Lands, Smithers
	1	Swan Lake Contracting, Hazelton
-Beales type	2	Ministry of Forests & Lands, Victoria
-West Fraser type	1	West Fraser Mills, Quesnel
-D7 V-plow	1	Peace Wood Products, Taylor
-Northwood type	1	Northwood, Houston
-Sanders type	2	H.E. Sanders Ltd., Merritt
-Skidder type	4	Tim Brown, Vanderhoof (contractor for Westar Timber)
C&H plow	2	Canfor, Fort St. John
	1	Netherlands Overseas Mill, Prince George
	2	Ministry of Forests & Lands, Prince George
	1	Ministry of Forests & Lands, Victoria
	1	Ministry of Forests & Lands, Smithers

TABLE 2. (Continued)

Equipment name	Number of units owned	Owner
Marttini plow	6	Alberta Forest Service, Edmonton
Ripper plow	4	Peace Wood Products, Taylor
	1	Ministry of Forests & Lands, Prince George
	1	Ministry of Forests & Lands, Fort St. John
	1	Ministry of Forests & Lands, Smithers
	1	Canfor, Fort St. John
Winged subsoiler	1	Ministry of Forests & Lands, Prince George
	1	Eagle Valley Holdings Ltd., Prince George
Eden rake (skidder type)	1	Ministry of Forests & Lands, Victoria
Eden relief bedding plow	0	available from Cazes & Heppner Forest Services Ltd., Clearbrook
Brush blades	1 or more	Most companies
FMC 6 Way Blade	1	Read Hedlund Logging, Midway
	1	Garry Glover Logging, Salmo
	1	George Veale Contracting, Balfour
FMC 4 Way Blade	1	Garry Glover Logging, Salmo
FMC with Brush Blade	1	MBM Contracting, Cranbrook
Anchor chains		Readily available from most companies and Forest Service
Sharkfin barrels		Readily available from most companies and Forest Service
Marden chopper	1	Ministry of Forests & Lands, Victoria
Madge rotary landbreaker	1	Dressler Services Ltd., Fort St. John
Downing chain	1	Ministry of Forests & Lands, Victoria
	1	Ministry of Forests & Lands, Prince George
Cat 205 excavator	1	Eagle Valley Holdings Ltd., Prince George
	1	Penny Contracting Ltd., Prince George
	1	Bob Murphy, Port McNeil
	1	Fulbrook Contracting Inc., Vernon
Cat 215 excavator	1	K. and M. Nicholson, Port McNeil
John Deere 490 (excavator)	1	R. W. R. Contracting Ltd., Prince George
	1	Eagle Valley Holdings Ltd., Prince George
John Deere 690B (excavator)	1	Philpot Forestry Services, Terrace

4 CHOOSING THE RIGHT EQUIPMENT FOR THE SITE

The first step in choosing an appropriate mechanical site preparation technique is to decide on the site preparation objectives. A list of objectives and the machines commonly employed to meet those objectives is provided in Section 4.1. Next, the best machine for the job can be selected by considering site characteristics. Constraints on machine operability and efficiency imposed by site conditions are presented in Table 3 in Section 4.2. Finally, Section 4.3 contains a summary of ecological "treatment units" found throughout north central British Columbia. Site preparation objectives and machines to meet these objectives are described for each treatment unit.

4.1 The Tool for the Job

A silviculturist must first define silvicultural objectives for the site, and then choose an appropriate method of site preparation. If the method chosen is mechanical site preparation, the objective will fall into one of the categories listed below. For most objectives, more than one machine is available for the task. The next step is to proceed to Section 4.2 and consider, for each activity, the soils and topographical features that affect machine choice. (Details on mechanical site preparation objectives are provided in Section 5.221 of the Silviculture Manual, B.C. Ministry of Forests and Lands).

1. *Increasing soil temperatures.* Soil temperatures limit the growing season for seedlings on many sites in north central British Columbia. Soil temperatures can be increased: by removing shading vegetation; by improving drainage on moist - wet sites; and by reducing forest floor depth through scalping, mixing, or inverting. Effective tools are agricultural discs and plows, Marttini plows, V-plows, C&H plow, mounders, brush blades, disc trenchers, ripper plows and patch scarifiers.

2. *Reducing drought.* On dry sites, moisture demands by competing vegetation may limit available moisture for conifer seedlings. Methods designed to reduce competing species can be effective in reducing drought stress of conifer seedlings, and in creating depressions or furrows that act as water catchments. Effective methods for consistently reducing drought stress have not been found, but ripper plows (eg., Sanders-Araki), scarifiers and disc trenchers have achieved variable success.

3. *Reducing grass competition.* Dense grass competes very effectively for soil moisture, nutrients and sunlight and may inhibit soil warming in areas of cold climate. Grass is also often responsible for mechanical damage in the form of snow press. Various pieces of machinery can achieve good control of grass competition for a short time. Effective machines include most scarifiers, mounders, and plows. The degree of control obtained depends on the size of the patch or furrow created, and on the size and abundance of the competing grass species. For example, control of bluejoint (*Calamagrostis canadensis*) in the Peace River country is often minimal with machines that create small screefed patches; control of the smaller pinegrass (*Calamagrostis rubescans*) in the Chilcotin is more effective.

4. *Reducing brush competition.* Some machines proven effective in reducing brush competition are agricultural discs and plows, Madge Rotoclear (limited use in forestry), V-plows, C&H plow, and Marttini plows. The FMC, brush blades and ripper plows have produced mixed results. As with grasses, the degree of control obtained depends on the nature of the shrub community and the extent of the cleared areas created.

5. *Reducing duff depth.* Reducing the insulating forest floor layer helps to warm the soil and allows trees to be planted in mineral soil. Effective machines for the purpose are the same as those suggested for increasing soil temperatures.

6. *Providing raised planting spots to improve soil drainage.* Mounders (including excavators), agricultural single bottom plows, Marttini plows, ripper plows, and trenchers will provide some elevation above the water table, but results have been variable.

7. *Reducing slash.* Brush blades, FMC, V-plows, and the C&H plow have proven effective at this task. Disc trenchers and patch scarifiers (including excavators) have produced mixed results.

8. *Incorporating mineral and organic layers.* Mixing or inverting the planting medium can improve seedling nutrition. Agricultural discs and plows and the Madge Rotoclear provide consistently good results in this regard; blades, plows, and disc trenchers, as well as drag scarification equipment, provide variable results.

9. *Scattering lodgepole pine cones and exposing mineral soil.* Drag scarification devices (anchor chain, sharkfin barrels) are effective. The Marden chopper has provided variable slash distribution and soil exposure.

10. *Breaking up a dense root mat.* Ripper plow is recommended.

11. *Shattering compacted soils.* Winged subsoiler is recommended.

12. *Knocking down standing trees.* Marden chopper (for small diameter stems) and the Downing chain (for larger stems) are recommended.

4.2 The Tool for the Site

Table 3 lists each machine included in this guide and summarizes its ability to perform under a variety of site conditions. For most site preparation objectives, several machines will be potentially useful. Knowing the physical characteristics of a site, its slope, soil moisture, brush, and slash loading, one can quickly determine which of these machines are physically capable of treating the site.

TABLE 3. Comparison of equipment capabilities

	Site Characteristics					
Equipment	**Terrain**	**Slope**	**Rockiness and stoniness**	**Soil texture**	**Soil moisture & drainage**	**Soil depth**
Lano	performs well wherever prime mover can go	contouring: max. 20-25%; straight downhill: up to 60%	performs well but tines worn if extremely rocky; can be raised to avoid large rocks	no limitations; best on loamy and sandy soils	prime mover restricted	limited only on extremely shallow soils (skips over shallow spots)
Bracke (Bracke mounder)	best on even to rolling terrain; fair to poor elsewhere	contouring: max. 20%; straight downhill: up to 40%	tines (shovels) worn if very rocky, but otherwise performs well	no limitations; best on loamy and sandy soils	rubber tires can become mired in wet soils	limited only on extremely shallow soils (Bracke mounder does not work well in shallow soils)
TTS disc trencher	can operate wherever prime mover can go; may overturn on rough sites	up to 25-30%	damage and wear to discs will occur if excessively rocky or stony	works well on wide range of soil textures	prime mover restricted	significant damage and wear occur on soils less than 20 cm deep
CFE disc trencher	can operate wherever prime mover can go; best on even to rolling terrain	up to 25-30%	damage and wear to discs will occur if excessively rocky or stony	works well on wide range of soil textures	prime mover restricted	significant damage and wear occur on soils less than 20 cm deep

TABLE 3. (continued)

	Site Characteristics					
Equipment	**Terrain**	**Slope**	**Rockiness and stoniness**	**Soil texture**	**Soil moisture & drainage**	**Soil depth**
Eden piling rake	best on even to rolling terrain; fair (poor) on more difficult terrain	on crawler: best on slopes up to 30%; on skidder: best on slopes up to 15%	no major limitations; teeth retract when they encounter obstacles	no major limitations	prime mover restricted	no major limitations (operator must set blade to avoid scalping shallow soil)
Brush blades	best on even to rolling terrain; fair (poor) on more difficult terrain	best on slopes up to 30%, max. 40%; contouring: up to 20-25%	no limitations	no limitations but may cause compaction or rutting of fine-textured soils	prime mover restricted	no major limitations (operator must set blade to avoid scalping shallow soil)
FMC with 4- or 6-way blade	good in all terrain types although less so in gullied and broken terrain	contouring: 35-45%; dip and dive: up to 70% (tilting blade works well on on contours)	does not perform well on very rocky sites; track assembly becomes worn	no limitations; causes less compaction of fine-textured soils than other prime movers	can work in much wetter ground than other prime movers; works on high water table sites	does not perform well where bedrock is exposed (poor traction)

TABLE 3. (continued)

	Site Characteristics					
Equipment	**Terrain**	**Slope**	**Rockiness and stoniness**	**Soil texture**	**Soil moisture & drainage**	**Soil depth**
V-plows: -Beales type -Muir's type -West Fraser type	best on even and rolling terrain; fair to poor elsewhere	contouring: max. 15-20%; angle contour: 20-25%; straight downhill: up to 40% However, potential for erosion is high.	no significant limitations but rocks cause wear on cutting blades	each soil type must be treated differently; operator training is essential	prime mover restricted (adds weight) operates on frozen soil; should not be used on wet ground	do not use on shallow soils!
C&H plow	best on even and rolling terrain; poor elsewhere		no significant limitations but rocks cause wear on cutting blades	(this heavy equipment has low traction on organic soils)		do not use on shallow soils!
Marttini plow	best on even and rolling terrain;poor elsewhere	up to 20%, slopes only	rocky soils are very hard on the cutting edges	generally used on fine or organic soils; some glazing on clay soils	prime mover restricted	do not use on shallow soils!
Ripper plow	best on even and rolling terrain; poor elsewhere	best on 5-10% slopes; work should angle across contour on any slope	rocky soils cause wear on tooth and may break tooth	generally used on fine or organic soils; some glazing on clay soils; will produce a good trench in sandy soil	treatment is generally done on frozen ground	do not use on shallow soils!

TABLE 3. (continued)

	Site Characteristics					
Equipment	**Terrain**	**Slope**	**Rockiness and stoniness**	**Soil texture**	**Soil moisture & drainage**	**Soil depth**
Anchor chain drag scarifier	best on even and rolling terrain; poor elsewhere	contouring: up to 15-20%; max. up to 40% but difficult over 25%	no limitations	best on loams and coarser textured soils	prime mover restricted (generally used only on dry ground)	no limitations
Sharkfin barrels	best on even and rolling terrain; poor elsewhere	less than 10%; above 10% can only be used where erosion is not a concern	no limitations	best on loams and finer textures; can compact or glaze clay soils	prime mover restricted (generally used only on dry ground)	no major limitations
Marden chopper	best on even terrain; poor elsewhere	use on flat ground; can go up slopes to 15%	bouncing can occur on stony soils - hard on operator; rocks cause blades to dull	best on loam; or slightly coarser textured soils	prime mover restricted; can bog down in wet soil	do not use where frequent bedrock outcrops occur
Agricultural discs, plows and landbreakers	generally should be restricted to even terrain	use on flat ground up to 10%	rocks cause blades to dull; not suitable for very rocky or stony sites	best on loam and finer soil textures	prime mover restricted; not suitable for wet soil	variable; care must be taken on shallow soils

TABLE 3. (continued)

Equipment	Site characteristics					
	Organic matter depth	Slash	Stumps	Ground vegetation cover	Residuals	Season of use
Eden piling rake	removes up to 20-25 cm	best in light to medium slash; has difficulty in heavy slash	blade rides over stumps because of hydraulic teeth	no limitations; can remove heavy brush	no limitations	can be used in any season; not suitable for soil scarification in winter
Brush blades	removes up to 20-25 cm	no limitations	avoid uprooting large stumps; piling difficult if stumps closely spaced and taller than 0.6 m	no limitations can remove heavy brush	no limitations	can be used in any season; not suitable for soil scarification in winter
FMC with 6-way blade	removes up to 20-25 cm	no limitations	can treat area with high or large stumps better than brush blade	no limitations; can remove heavy brush	no limitations	can be used in any season; not suitable for soil scarification in winter
V-plows: -Beales type -Muir's type -West Fraser type	no limitations; removes up to 30 cm	excellent in light to medium slash but reduced production in heavy slash (especially on steeper slopes)	generally not a problem until stumps exceed 60 cm in height or 30 cm in diam.	no limitations can remove heavy brush	no significant problems unless more than 100/ha	good machines for winter use on ground that is not accessible in other seasons; otherwise use at driest time of year

TABLE 3. (continued)

Equipment	Site characteristics: Organic matter depth	Slash	Stumps	Ground vegetation cover	Residuals	Season of use
C&H plow	removes up to 20-30 cm	excellent in light to medium slash but reduced production in heavy slash (especially on steeper slopes)	generally not a problem until stumps exceed 60 cm in height or 30 cm in diam.	no limitations can remove heavy brush	no limitations in small residuals, but not very manoeuvrable around larger trees. Tall residuals or saplings fall back on previous trails.	good machines for winter use on ground that is not accessible in other seasons; otherwise use at driest time of year
Marttini plow	removed up to 40 cm easily, but poor when less than 5 cm	recommended for light slash conditions only	medium to large stumps restrict plow movement	no major limitations	no major limitations	use at driest time of year
Ripper plows	removes up to 30-40 cm	best in light to medium slash; if heavier, prime mover must have a blade	splits stumps; mostly prime mover restricted	in heavy grass the sod may turn back into the furrow	if heavy, will require removal or plow will ride up onto residuals	any time when ground is frozen
Anchor chain drag scarifier	removes up to 10 cm only, depending on weight of drag	handles light to medium slash; not effective in heavy slash	should not be more than 20 cm high and 30 cm in diameter	most effective where there is no grass and herbs and brush are light	no major limitations unless frequent and large	spring, summer or fall (used on dry sites)

TABLE 3. (continued)

Equipment	Site characteristics: Organic matter depth	Slash	Stumps	Ground vegetation cover	Residuals	Season of use
Leno	removes up to 15 cm; attachment for deeper scarification	works in light to medium slash; prime mover must clear pack in heavy slash	will ride over low stumps; mainly a prime mover problem	limited only in heavy brush; in heavy grass, sod may flip back over onto patch	limited by prime mover (manoeuvres well)	not used on frozen ground or snow; otherwise prime mover restricted
Bracke (Bracke mounder)	removes up to 20 cm	works in light to medium slash; prime mover must clear pack in heavy slash	medium stumps a problem; large stumps cause serious difficulties	no limitations	dense residuals impair performance (not very manoeuvrable)	not used on frozen ground or snow; otherwise prime mover restricted
TTS disc trencher	removes up to 15 - 20 cm; extra weight can be added for deeper scarification	works in light to medium slash; prime mover must clear pack in heavy slash	rides over most stumps; mainly a prime mover problem	no limitations except in heavy brush	no significant limitations	not used on frozen ground or snow; otherwise prime mover restricted
CFE disc trencher	removes up to 15-20 cm	works in light to medium slash; prime mover must clear pack in heavy slash	rides over most stumps mainly a prime mover problem	no limitations except in heavy brush	no significant limitaitons	not used on frozen ground or snow; otherwise prime mover restricted

TABLE 3. (concluded)

Site characteristics						
Equipment	Organic matter depth	Slash	Stumps	Ground vegetation cover	Residuals	Season of use
Sharkfin barrels	removes up to 20 cm	good in light to medium slash; will work in heavy slash	prime mover restricted; if large, use triangular boat ahead of barrels	effective in light to medium vegetation	prime mover restricted	use at driest times of year; works in light snow
Marden chopper	not usually used to reduce organic matter; ie., rides up on slash	only limited by large piece size, not by high density	mostly prime mover restricted; high stumps cause problems	no limitations	prime mover restricted (not manoeuvrable around large trees)	dry season or frozen ground (no snow)
Agricultural discs, plows and landbreakers	generally work well up to 30 cm	restricted to light slash areas	with the exception of the Eden bedding plow, discs do not work on sites with stumps	no major limitations unless brush excessively heavy	generally do not work well in residuals	dry season or lightly frozen ground

4.3 Mechanical Site Preparation Treatment Units for North Central British Columbia

This section uses the biogeoclimatic classification system to summarize the ecological factors that must be considered when a prescription for mechanical site preparation is made for a site. Field personnel should use these interpretations together with the Ecological Classification manuals for their area, and not as a substitute for them.

The geographic area encompassed by the guide includes biogeoclimatic units of the Sub-Boreal Spruce Zone (SBS) except for the SBSa and SBSb, the Interior Cedar - Hemlock Zone (ICH), the Engelmann Spruce - Subalpine Fir Zone (ESSF), and the Boreal White and Black Spruce Zone (BWBS) found in the Cariboo, Prince George, and Prince Rupert Forest Regions. The IDF zone has not been included.

Within the SBS, ICH, ESSF, and BWBS more than 40 biogeoclimatic units have been identified and described to some degree. With an average of eight ecosystem associations (= site series) in each subzone or variant, the total number of unique ecological units becomes very large, and quite unmanageable for a field guide intended to cover a large geographic area. To reduce this complexity, ecosystem associations from various biogeoclimatic units, having similar ecological properties in terms of mechanical site preparation, have been grouped into "treatment units". Each treatment unit has been given a colloquial name (e.g., Treatment Unit 2: Dry Fluvial Pine Treatment Unit), and a table summarizing the units is presented on page 49-50.

The interpretations for each treatment unit consist of:

1. Site Characteristics: a summary of typical physical characteristics of the treatment units that may be important for mechanical site preparation. These characteristics vary somewhat from site to site, but should be sufficiently distinct to characterize an area. Foresters not familiar with ecosystem units in their area should consult the ecological classification manuals for their area to identify ecosystems. These characteristics, particularly with respect to Ecological Moisture Regime, are relative within north central British Columbia.

2. Site Preparation Objectives: a list of possible biological and silvicultural reasons for treating (or not treating) a site.

3. Interpretations: a summary of important factors that must be considered in making ecologically sound and silviculturally successful prescriptions for mechanical site preparation.

4. Equipment Recommendations: suggestions for mechanical site preparation equipment that may be suitable for treating the site, based on user experience and ecological considerations.

When Section 4.3 is used to prepare a prescription, the following points should be remembered:

- The recommendations included here are intended as a guide. In certain cases, logistical or economic factors not considered here will play a role in the final choice of treatment for a site. As well, specific objectives for treating the site may differ from those suggested for the treatment unit.

- The recommendations presented here emphasize mechanical site preparation, since that is the subject of the guide. In many cases, alternative site preparation methods such as slashburning may be selected over mechanical site preparation.

- Most cutblocks are a complex of several different ecosystem units. The field forester must decide whether these differences warrant separating the block into several treatment units, applying a blanket treatment based on the dominant ecosystem unit in the block, or carrying out a single treatment but leaving small pockets untreated.

- Most site preparation equipment will operate optimally on gently sloping, more or less mesic sites, with deep medium-textured soils and no excess of brush, deep duff, slash, or large stumps. On such sites, equipment decisions will probably be based more on factors such as availability, experience, and cost-effectiveness than on ecological considerations. It is on the steep, brushy, wet, or otherwise difficult sites that the choice and use of equipment will be critical. Unfortunately, the choice of suitable equipment for such sites is limited, and experience in how to use that equipment correctly is only recently developing. Important decisions are selection of an appropriate prime mover, selection of an experienced and careful operator, and selection of proper timing of the project to take advantage of changing soil moisture conditions.

Table 4. Characteristics of mechanical site preparation treatment units

Treatment Unit	Very Dry Lichen	Dry Fluvial Pine	Dry Non-Fluvial Pine	Dry Douglas-fir	Hemlock - Moss	Engelmann Spruce - Rhododendron	Pine-Black Spruce	Mesic	Wetter Shrub	Horsetail	Floodplain Cottonwood Seral
Represent-ative Ecosystem Units	BWBSc1/02, BWBSe/02, ESSFh1/02, ESSFk/02, ICHg1/02, ICHh1/02, SBSc/02, SBSe1/02, SBSj1/02	BWBSc1/03, BWBSe/03, SBSc/05, SBSe1/03, SBSj1/03, SBSk3/03	ESSFk/03	ICHh1/03, ICHj1/02, SBSc/04, SBSj1/05, SBSk3/02	ICHg1/01, ICHh1/04, ICHj/03	ESSFh1/03, ESSFh3/02	BWBSc1/04, BWBSe/05, SBSe1/05, SBSk3/05	BWBSc1/01, BWBSe/01, ESSFk/01, SBSc/01, SBSe1/01, SBSj1/04, SBSk3/01	BWBSc1/05, ESSFh1/05, ESSFh3/03, ESSFk/07, ICHg1/05, ICHh1/07, ICHj/05, SBSc/08, SBSe1/08, SBSj1/08, SBSk3/07	BWBSc1/07, BWBSe/06 ESSFh1/07, ESSFh3/05, ESSFk/09, ICHg1/06, ICHh1/08, ICHj/06, SBSc/09, SBSe1/09, SBSj1/10, SBSk3/08	SBSd/10, ICHg1/07
Terrain	broken rocky ridges	usually level or ridged	broken, rolling	broken, often gullied	mid to upper slopes and ridge crests	broken, rolling	level to gently rolling	variable, usually rolling	variable, rolling to gullied	level or rolling	valley floors
Slope	usually 0-25%	usually 0-20%	variable (0-60%)	steep (30-80%)	variable (0-70%)	variable (0-55%)	gentle (0-10%)	variable (usually gentle)	0-50% (usu. less than 20%)	0-10% (usu. less than 5%)	level
Soil texture	coarse	coarse (sandy)	variable	medium to coarse	medium to coarse	medium to coarse	variable	variable	variable	variable	variable
Ecological Moisture Regime	very dry to dry	very dry to dry	dry to medium	very dry to dry	very dry to dry	dry to medium	dry to wet	medium	medium to wet	very wet	variable
Ecological Nutrient Regime	very poor to poor	poor	poor to medium	poor	poor to medium	poor to medium	poor to very poor	medium	medium to rich	medium to rich	rich

Table 4 (Continued)

Traffic-ability	poor to fair (rocky)	excellent	fair to good	fair to poor	usually good	fair to poor	poor to good	good to fair	fair	usually poor	usually good
Humus Depth	very thin (less than 5 cm)	thin (3-5 cm)	moderately thin (less than 5 cm)	moderately thin (2-8 cm)	thin (0-6 cm)	thin (2-5 cm)	moderate (5-10 cm)	moderate (5-10 cm)	moderately deep (5-25 cm)	usually deep (0-90 cm)	very thin or absent
Slash	light	light	light to moderate	light to moderate	light to moderate	light to moderate	variable, usually moderate	light to moderate	moderate to heavy	moderate to heavy	usually heavy
Stumps	few, small	small, often dense	few, small	few, usually quite large	usually small and widely spaced	few, small to large	usually small	moderate	moderately large	large, often high	few, large
Competing vegetation	very light	light	usually light	light	light	often high	light	moderate	moderately high to extreme	moderate to high	heavy
Other identifying features	The very driest sites; *Cladina* lichens predominant in moss layer; usually non-commercial	Fluvial or glacio-fluvial landforms & soils	Dry sites, not as dry as Unit 1, with glacio-fluvial parent materials as on Unit 2	Douglas-fir canopy prior to harvesting; often managed as uneven-aged stands	Hemlock canopy prior to harvesting; very little understory, restricted to ICH	Engelmann spruce canopy prior to harvesting; understory dominated by dense cover of rhododendron; restricted to ESSF	Pine - black spruce canopy prior to harvesting; rooting depth restricted by fluctuating water table or compact soil horizons	Sites with average ecological moisture regime in all but the very wettest & driest BWBS, ESSF, ICH, & SBS units	Wet sites, with larger ferns (*Athyrium*, *Dryopteris*) & sometimes devil's club (*Oplopanax*) prior to harvesting	Very wet sites, water table at or just below surface, horsetail abundant prior to harvesting	Cottonwood canopy prior to harvesting; on valley floors

1. Very Dry Lichen Treatment Unit

Representative Ecosystem Associations:
BWBSc1/02, BWBSe/02, ESSFh1/02, ESSFk/02, ICHg1/02, ICHh1/02, SBSc/02, SBSe1/02, SBSj1/02

SITE CHARACTERISTICS

Terrain:	- broken, rocky ridges
Slope:	- variable, 0-75%, often steep, convex
Soils:	- medium- to coarse-textured, usually shallow over bedrock, with a high % coarse fragments
Soil Drainage:	- rapid
Ecological Moisture Regime:	- very dry to dry
Ecological Nutrient Regime:	- very poor to poor
Conditions for Traffic:	- poor to fair (rocky)
Humus Depth:	- very thin, less than 5 cm
Slash:	- light
Stumps:	- few, small
Competing Vegetation:	- very light

SITE PREPARATION OBJECTIVES

Conserve humus; minimize erosion; reduce drought; shade seedlings; promote natural regeneration.

INTERPRETATIONS

These associations are mostly non-commercial forest, but small units may occur as inclusions of larger blocks. Site preparation should not be required and use of machines must be avoided because of the shallow soils, thin humus forms, and severe erosion potential.

EQUIPMENT RECOMMENDATIONS

No mechanical site preparation.

2. Dry Fluvial Pine Treatment Unit

Representative Ecosystem Associations:
BWBSc1/03, BWBSe/03, SBSc/05, SBSe1/03, SBSj1/03, SBSk3/03

SITE CHARACTERISTICS

Terrain:	- usually level or ridged, occasionally slightly rolling
Slope:	- usually 0-20%
Soils	- coarse-textured (sandy), often with a high % of rounded cobbles or gravels
Soil Drainage:	- well to rapidly drained
Ecological Moisture Regime:	- very dry to dry
Ecological Nutrient Regime:	- poor
Conditions for Traffic:	- excellent
Humus Depth:	- thin, 3-5 cm
Slash:	- light
Stumps:	- small, often dense
Competing Vegetation:	- light

SITE PREPARATION OBJECTIVES

Conserve organic layers; promote natural lodgepole pine regeneration while preventing overstocking; control mistletoe; reduce grass or aspen competition; remove undesirable (Hw, Bl) regeneration where appropriate.

INTERPRETATIONS

Conditions and access for equipment traffic on these sites are excellent; however, unnecessary use of heavy equipment must be avoided to protect organic layers and surface soil layers. No site preparation is usually required before planting. Natural Pl regeneration can often be achieved, but excessive exposure of mineral soil may lead to overstocking. Mixing of organic and mineral soils can improve soil nutrition, temperature, and moisture for seedling growth. Some form of site treatment may be required to reduce fire or mistletoe hazards. Low priority for site preparation.

EQUIPMENT RECOMMENDATIONS

Anchor chain drag as required for natural regeneration. Winter shearing and windrowing or Marden chopper for rehabilitation. Brush blade or Eden rake if necessary to remove slash. Do not scalp.

3. Dry Non-Fluvial Pine Treatment Unit

Representative Ecosystem Associations:
ESSFk/03

SITE CHARACTERISTICS

Terrain:	- broken, rolling
Slope	- variable, 0-60%
Soils:	- texture variable, moderately fine to coarse; coarse fragements also variable but usually more abundant in wetter biogeoclimatic units
Soil Drainage:	- well to rapidly drained (moderately well drained on moderately fine-textured soils), though ESSF units will be moist well into the growing season because of snow load
Ecological Moisture Regime:	- dry to medium
Ecological Nutrient Regime:	- poor to medium
Conditions for Traffic:	- fair to good, depending on slope, soil depth and soil texture
Humus Depth:	- moderately thin, usually less than 5 cm
Slash:	- light to moderate
Stumps:	- few, small
Competing Vegetation:	- usually light; aspen and bluejoint in the Peace, rhododendron and black huckleberry in the ESSF, and alders in the SBS have the potential to be serious competitors on these drier sites

SITE PREPARATION OBJECTIVES

Conserve organic layers; minimize erosion; promote natural Pl regeneration; improve planter access and prepare plantable spots where appropriate; improve soil temperature; remove advance Bl regeneration where appropriate.

INTERPRETATIONS

This treatment unit includes a diverse group of site series (ecosystem associations) of dry to medium moisture regimes, characterized by pyroclimax or edaphic climax forests dominated by lodgepole pine. Individual sites range from steep sites with coarse-textured, stony soils, to more level sites with finer-textured soils. (Pine-dominated sites occurring on fluvial fans or terraces are described in Treatment Unit 2). Pine will regenerate naturally on most sites, though serotiny may be a problem in some areas. Only sites that have been winter logged will require site preparation to facilitate planting. On steeper slopes with a high percentage of coarse fragments, mechanical site preparation should be avoided; otherwise, these sites are well suited to mechanical site preparation, though some compaction may occur on finer-textured soils when moist. Where feasible, mixing of organic and mineral soil can improve moisture, temperature, and nutrient status for the seedling. Brush may need to be treated on some sites, but in general, competition from non-crop species should be light.

EQUIPMENT RECOMMENDATIONS

Mechanical site preparation is not recommended on sites with steep slopes or shallow soils in this treatment unit. For natural regeneration, anchor chain drag scarification is commonly used on gentler slopes with deeper soils; patch scarifiers (disc trenchers if the terrain is not too stony), brush blades or Eden rakes may be appropriate in heavier slash conditions. It is important to retain soil organic matter on these sites.

4. Dry Douglas-fir Treatment Unit

Representative Ecosystem Associations:
ICHh1/03, ICHj1/02, SBSc/04, SBSj1/05, SBSk3/02

SITE CHARACTERISTICS

Terrain:	- broken, often gullied, steep
Slope:	- steep, 30-80%
Soils:	- medium- to coarse-textured, with a high % of angular coarse fragments
Soil Drainage:	- rapid
Characteristic Vegetation:	- Douglas-fir canopy
Ecological Moisture Regime:	- very dry to dry
Ecological Nutrient Regime:	- poor
Conditions for Traffic:	- fair to poor (steep, stony)
Humus Depth:	- moderately thin, 2-8 cm
Slash:	- light to moderate
Stumps:	- few, usually quite large
Competing Vegetation:	- light, occasionally some grass competition on south-facing slopes

SITE PREPARATION OBJECTIVES

Conserve organic layers; minimize erosion; improve moisture availability; provide (inanimate) shade for seedlings; promote natural Pl or Fd regeneration (some sites); protect advance Fd regeneration (primarily in the Cariboo); prepare planting spots (some sites). Many of these sites in the Cariboo Region are managed by uneven-aged management.

INTERPRETATIONS

Steep slopes, shallow soils, and erosion potential make most of these sites unsuitable for heavy machinery. Site preparation should not be required to facilitate planting since soil organic layers are shallow and competing vegetation is light; some treatment may be necessary if slash is moderate. Slash will provide needed shade for seedlings, but may be an unacceptable fire hazard.

EQUIPMENT RECOMMENDATIONS

Plantable spots can be created with a Leno to reduce grass/shrub competition for moisture. Plant in scalped patches.

5. Hemlock - Moss Treatment Unit (restricted to the ICH)

Representative Ecosystem Associations:
ICHg1/01, ICHh1/04, ICHj/03

SITE CHARACTERISTICS

Terrain:	- mid to upper slopes and ridge crests; some terraces and benches
Slope:	- variable (0-70%)
Soils:	- medium- to coarse-textured (occasionally moderately fine-textured), high coarse fragment %, sometimes shallow to bedrock
Soil Drainage:	- well to rapidly drained
Ecological Moisture Regime:	- very dry to dry
Ecological Nutrient Regime:	- poor to medium
Conditions for Traffic:	- usually good; fair to poor on steep slopes or finer-textured soils
Humus Depth:	- shallow (0-6 cm)
Slash:	- light to moderate
Stumps:	- usually small and widely spaced
Competing Vegetation:	- light

SITE PREPARATION OBJECTIVES

Mechanical site preparation should be avoided on steeper slopes or on shallow-to-bedrock soils. On other sites, objectives are: conserve organic layers; minimize erosion; reduce drought; promote natural regeneration where Pl or Fd is present; mix organic and mineral soils; remove undesirable advance regeneration (Hw, Bl) on most sites (though Hw regeneration may be protected in the ICHg); prepare planting spots; improve planting access. Mechanical site preparation should also be avoided on sites where acceptable advanced regeneration must be protected.

INTERPRETATIONS

This treatment unit includes a diverse group of site series (ecosystem associations), of dry to medium moisture regimes, characterized by climax forests dominated by western hemlock (*Tsuga heterophylla*), with very poorly developed shrub and herb layers, and well-developed moss layers.

Individual sites range from steep sites with coarse-textured, stony soils, to more level sites with finer-textured soils.

Pine may regenerate naturally on most sites, other sites may require planting, and management of some sites in the ICHg may consist of protecting acceptable advanced regeneration of Hw or Sx.

On steeper slopes with a high percentage of coarse fragments, mechanical site preparation should be avoided; otherwise, these sites are well suited to mechanical site preparation, though some compaction may occur on finer-textured soils when moist. Where feasible, mixing of organic and mineral soil can improve moisture, temperature, and nutrient status for the seedling. Brush may need to be treated on some sites (fireweed may be heavy on north aspects in the ICH), but in general, competition from non-crop species should be light.

EQUIPMENT RECOMMENDATIONS

No mechanical site preparation should be attempted on sites with steep slopes or shallow soils in this treatment unit. For natural regeneration of Pl where a seed source is available, anchor chain drag scarification is commonly used on gentler slopes with deeper soils; patch scarifiers (disc trenchers if the terrain is not too stony), brush blades, or Eden rakes may be appropriate in heavier slash conditions. It is important to maintain soil organic layers on these sites.

6. Engelmann Spruce - Rhododendron Treatment Unit (restricted to the ESSF)

Representative Ecosystem Associations:
ESSFh1/03, ESSFh3/02

SITE CHARACTERISTICS

Terrain:	- broken, rolling
Slope:	- variable, 0-55%
Soils:	- medium- to coarse-textured, often with a high % coarse fragments or shallow over bedrock
Soil Drainage:	- well to rapidly drained, but moist well into the growing season because of the snow load
Ecological Moisture Regime:	- dry to medium (but see 'Soil Drainage')
Ecological Nutrient Regime:	- poor to medium
Characteristic Vegetation:	- canopy of Engelmann spruce/subalpine fir with abundant white-flowered rhododendron (*Rhododendron albiflorum*) in the understory
Conditions for Traffic:	- fair to poor, depending on steepness and soil depth
Humus Depth:	- thin, 2-5 cm
Slash:	- light to moderate
Stumps:	- few, small to large
Competing Vegetation:	- often dense cover of rhododendron and black huckleberry (*Vaccinium membranaceum*)

SITE PREPARATION OBJECTIVES

Protect shallow soils; promote natural regeneration on some sites; improve planter access; prepare planting spots; protect soil organic layers; improve soil temperature and/or nutrient status.

INTERPRETATIONS

These sites may have shallow soils and are particularly susceptible to erosion. Mechanical site preparation is not recommended except on gentle slopes with deeper soils. Site preparation should not be required to facilitate planting unless slash is heavy. Dense brush can be a problem, but rhododendron is slow growing and seems to be fairly well controlled by most site preparation techniques. Localized mounding or mixing of soil may be desirable, on moist soils with loamy or finer-textured capping, to improve soil temperature and fertility.

EQUIPMENT RECOMMENDATIONS

On steep slopes and/or shallow soils, no mechanical treatment is recommended. On gentle slopes with deeper soils, patch scarifiers (or disc trenchers if the ground is not too stony) should be appropriate. Brush blades or Eden rakes may be necessary where slash is heavy. Extreme care must be taken to conserve soil organic matter.

7. Pine - Black Spruce Treatment Unit

Representative Ecosystem Associations:
BWBSc1/04, BWBSe/05, SBSe1/05, SBSk3/05

SITE CHARACTERISTICS

Terrain:	- level to gently rolling
Slope:	- gentle (0-10%)
Soils:	- coarse to fine-textured, compact subsurface layers common; coarse fragments variable
Soil Drainage:	- moderately well to imperfectly drained
Characteristic Vegetation:	- lodgepole pine/black spruce canopy
Ecological Moisture Regime:	- dry to wet
Ecological Nutrient Regime:	- poor to very poor
Conditions for Traffic:	- poor to good (depending on soil texture and season)
Humus Depth:	- moderate (5-16 cm)
Slash:	- variable, usually moderate
Stumps:	- moderate, usually small (depends on season of logging)
Competing Vegetation:	- light

SITE PREPARATION OBJECTIVES

Prepare planting spots (raised above seasonally wet spots); promote natural pine regeneration; avoid soil compaction; improve soil temperature; improve planter access.

INTERPRETATIONS

The pine-black spruce unit includes a variety of sites with submesic to subhygric moisture regimes, and poor nutrient regimes. Site preparation is usually not required to achieve natural regeneration of Pl and, given the usually low productivity of these sites, pine - black spruce treatment units are often a low priority for site preparation. Mixing of organic and surface mineral soil to promote natural regeneration may also improve fertility and cold soil temperatures. Where planting is desired, creation of mounded planting spots is recommended. Pine - black spruce treatment units occur on coarse-textured and fine-textured soils. Mounding on fine-textured soils should take place in the driest part of the year, and planting should be on the mounds rather than on the subsurface soil, which may be impermeable to roots. Mounding on medium- to coarse-textured soils can take place in any season, but drying out of the mounds may be a problem.

EQUIPMENT RECOMMENDATIONS

If the silvicultural goal is natural regeneration, anchor chain drag scarification (or no site preparation) is appropriate. If the goal is to plant, disc trenchers and patch scarifiers may be used to prepare planting spots in lighter slash. For heavier slash loads, a brush blade is recommended. On moister sites, mounders may create ideal raised planting spots. Sites with poor conditions and access for equipment traffic can be treated in summer with an FMC with 4- or 6-way blade; the blade should try to create planting mounds. A ripper plow is the recommended treatment for sites with heavy organic layers that are accessible only in winter.

8. Mesic Treatment Unit

Representative Ecosystem Associations:
BWBSc1/01, BWBSe/01, ESSFk/01, SBSc/01, SBSe1/01, SBSj1/04, SBSk3/01

SITE CHARACTERISTICS

Terrain:	- variable, usually rolling
Slope:	- variable, usually gentle (less than 20%)
Soils:	- variable; not shallow to bedrock or excessively stony; moderately coarse to moderately fine, usually medium
Soil Drainage:	- moderately well to well drained
Ecological Moisture Regime:	- medium
Ecological Nutrient Regime:	- medium
Conditions for Traffic:	- good to fair, depending on soil texture and slope
Humus Depth:	- moderate, usually 5-10 cm
Slash:	- light to moderate; may depend on the volume of deciduous left behind
Stumps:	- moderate
Competing Vegetation:	- moderate, aspen can be a problem

SITE PREPARATION OBJECTIVES

Prepare planting spots; improve planter access; reduce brush competition; improve soil temperature; remove (SBS, ICH) or protect (ESSF occasionally) advance BI regeneration; reduce fire hazard; avoid soil compaction and rutting on fine-textured soils; minimize aspen, alder, willow and grass invasion; protect surface organic layers (where required).

INTERPRETATIONS

In general, only sites which have been winter logged will require site preparation to facilitate planting. These sites are suitable for mechanical site preparation except where extreme slopes, rugged terrain or shallow soils are present. Choice of machine will probably depend on slope, stumps and slash loading constraints. Soils with fine-textured surface horizons can occur and are subject to compaction when wet.

EQUIPMENT RECOMMENDATIONS

Patch scarifiers with a V-plow or angled brush blade should be used to realign slash where required. The FMC with 4- or 6-way blade (summer) or brush blade (frozen ground) should be used on wet, fine-textured soils and/or steeper slopes.

9. Wetter Shrub Treatment Unit

Representative Ecosystem Associations:
BWBSc1/05, ESSFh1/05, ESSFh3/03, ESSFk/07, ICHg1/05, ICHh1/07, ICHj/05, SBSc/08, SBSe1/08, SBSj1/08, SBSk3/07

SITE CHARACTERISTICS

Terrain:	- variable, rolling to gullied, occasionally even
Slope:	- 0-50%, usually less than 20%, lower slope to level slope position except in the wettest biogeoclimatic units (SBSj1; SBSj2; SBSf)
Soils:	- variable; coarse to fine, if coarse then in a receiving position; moist most of the year
Soil Drainage:	- moderately well to imperfectly drained
Ecological Moisture Regime:	- medium to wet
Ecological Nutrient Regime:	- medium to rich
Conditions for Traffic:	- fair on coarse-textured soils; poor on fine-textured soils
Humus Depth:	- moderate to deep, 5-25 cm
Slash:	- moderate to heavy
Stumps:	- moderately large, often winter logged
Competing Vegetation:	- brush hazard moderately high to extreme

SITE PREPARATION OBJECTIVES

Prepare planting spots; reduce brush competition; improve planter access; improve soil temperature; reduce fire hazard where required; remove Bl advance regeneration where appropriate.

INTERPRETATIONS

This treatment unit includes a large variety of mesic and wetter sites in the SBS, ICH, ESSF, and BWBS that have the same site preparation objectives and interpretations. Most site preparation on these sites at present is prescribed fire rather than mechanical. Mechanical site preparation is directed towards getting the seedlings out of the cold, wet soil, and controlling competing vegetation. Seedlings should be planted on mounds or berms rather than in depressions subject to seasonal flooding. Site preparation and planting should immediately follow harvesting to minimize brush problems. Planter trails will often be required because of heavy slash and brush. Timing of mechanical treatments during periods of low soil moisture is crucial on finer-textured soils. Follow-up brushing and weeding programs will often be required on these sites.

EQUIPMENT RECOMMENDATIONS

Brush blades (current logging) or V-plows (rehabilitation) are the most suitable equipment for preparing planting trails and reducing initial brush competition on sites with heavier slash and brush. Patch scarifiers with a V-plow or angled brush blade should be used to realign slash for sites with lighter slash and brush. The FMC with 4- or 6-way blade (summer) or brush blade (frozen ground) should be used on wet, fine-textured soils and/or steeper slopes. The ripper plow is appropriate for sites that are accessible only when frozen; this is extreme treatment, not generally recommended.

10. Horsetail Treatment Unit

Representative Ecosystem Associations:
BWBSc1/07, BWBSe/06, ESSFh1/07, ESSFh3/05, ESSFk/09, ICHg1/06, ICHh1/08, ICHj/06, SBSc/09, SBSe1/09, SBSj1/10, SBSk3/08

SITE CHARACTERISTICS

Terrain:	- level or rolling (often on the edge of flowing or standing water)
Slope:	- 0-10%, usually less than 5%
Soils:	- texture variable, usually either lacustrine and organic, or fluvial; may be gravelly below the surface layers
Soil Drainage:	- poorly to imperfectly drained, often wet throughout the growing season
Characteristic Vegetation:	- horsetails (*Equisetum* spp.) in the herb layer
Ecological Moisture Regime:	- very wet
Ecological Nutrient Regime:	- medium to rich

Conditions for Traffic:	- usually poor; occasionally good on coarse-textured soils in the dry season
Humus Depth:	- 0-90 cm, usually deep
Slash:	- moderate to heavy
Stumps:	- large, often high (the sites are usually winter logged)
Competing Vegetation:	- moderate to high brush hazard

SITE PREPARATION OBJECTIVES

Prepare raised planting spots to improve soil drainage; improve soil temperature; reduce brush competition; improve planter access. Draining may be an option on these sites, but there is no experience in the area.

INTERPRETATIONS

Coarse-textured (fluvial) soil phases: Conditions and access for equipment traffic on these sites is poor, but may be possible in the driest part of summer. Planting spots must be raised above the water table; unfortunately, these mounds will then be susceptible to drought on many sites.

Fine-textured (lacustrine) soil phases: These sites have extremely poor conditions for traffic and, in general, machinery cannot be used without causing unacceptable site degradation. Brush competition is generally severe. Organic layers may be too deep to allow some machines to operate effectively. Trees should be planted on naturally occurring elevated microsites where possible.

EQUIPMENT RECOMMENDATIONS

There has been very little successful experience with mechanical site preparation on this treatment unit. Equipment suitability depends on the depth of organic layer and the volume of slash. Site preparation on these sites should use low ground pressure prime movers, or take place on frozen ground. An FMC with 4- or 6-way blade can be used to prepare raised mounds. Ripper plows can be used on frozen ground. It has been suggested that an FMC with Bracke-mounder or disc trencher may have potential on sites with less than 20 cm of duff, but this has not been tested.

11. Floodplain Cottonwood Seral

Representative Ecosystem Associations:
SBSd/10, ICHg1/07

SITE CHARACTERISTICS

Terrain:	- valley floors
Slope:	- level (0-2%)
Soils:	- texture variable, often gravelly below surface soil layers; fluvial parent material
Soil Drainage:	- good to rapid
Ecological Moisture Regime:	- variable (seasonally submerged)
Ecological Nutrient Regime:	- rich
Characteristic Vegetation:	- canopy of cottonwood or balsam poplar (*Populus balsamifera*)
Conditions for Traffic:	- usually good
Humus Depth:	- very thin or absent
Slash:	- usually heavy
Stumps:	- few, large
Competing Vegetation:	- heavy

SITE PREPARATION OBJECTIVES

Convert to spruce; prepare planting spots (above floodwater level); reduce existing brush competition; minimize brush invasion; improve soil temperature; improve planter access.

INTERPRETATIONS

These are the brushiest and most productive site series (ecosystem associations) in the BWBS. Some form of site treatment will be required to establish a successful conifer plantation. However, mechanical site preparation is generally not the best method of treatment. Brush encroachment following logging will be rapid, and unless these sites are treated promptly, trails will be required for planter access. Because the organic layer is very thin, summer treatment will tend to intensify regrowth of brush. Follow-up brushing and weeding will usually be required after mechanical site preparation.

EQUIPMENT RECOMMENDATIONS

V-plows or brush blade on frozen ground.

5 FURTHER INFORMATION SOURCES

1. Publication: Scarification
   Available from: Skogsarbeten
   Logging Research Foundation
   Drottninggatan 97-S-113 60
   Stockholm, Sweden

   An excellent introductory manual discussing the principles and biological objectives of scarification. The manual also covers choosing the correct prime mover, operating and servicing equipment, and choosing the most effective operating pattern.

2. Publication: Drag Scarification in British Columbia
   Available from: B.C. Ministry of Forests and Lands
   Province of British Columbia
   Victoria, B.C. V8W 3E7
   Tel: 387-8909

   This manual discusses anchor chain drag and sharkfin barrel scarification in detail.

3. Publication: Guide to Mechanical Site Preparation in Northern Ontario
   Available from: Public Service Centre
   Ontario Ministry of Natural Resources
   Room 1640, Whitney Block, Queens Park,
   Toronto, Ont. M7A 1W3
   Tel: (416) 965-9751

   A manual that describes many pieces of equipment currently used in British Columbia. This is an excellent manual that is similar in format to this guide. Equipment descriptions can be purchased individually or the whole manual can be obtained from the above address.

4. Publication: Silviculture Manual
   Available from: B.C. Ministry of Forests and Lands
   Province of British Columbia
   Victoria, B.C. V8W 3E7
   Tel: 387-8907

   Chapter 5 discusses the biological objectives of mechanical site preparation and includes a description of various pieces of equipment.

5. Organization: Missoula Equipment Development Centre
   U.S. Department of Agriculture
   Bldg. 1, Ft. Missoula,
   Missoula, Mont. USA 59801
   Tel: (406) 329-3157

   This organization puts out various mechanical site preparation manuals in the United States and does research on methods of mechanical site preparation. They are currently researching and developing equipment for patch scarification.

6. Organization: Equipment Development Centre
   U.S. Forest Service
   444 East Bonita Avenue,
   San Dimas, Cal. USA 91773
   Tel: (714) 599-1267

   This organization researches and develops silvicultural equipment used in the United States.

7. Organization: Forest Engineering Research Institute of Canada (FERIC)
201-2112 West Broadway,
Vancouver, B.C. V6K 2C8
Tel: 732-3711

This organization researches and develops silviculture equipment used in Canada. FERIC has also produced a number of recent publications on site preparation equipment used in British Columbia.

8. Newsletter: Mechanization of Silviculture Newsletter
Available from: Mr. M. Ryans
Forest Engineering Research Institute of Canada (FERIC)
143 Place Frontenac,
Pointe Claire, Que. H9R 4Z7
Tel: (514) 694-1140

A semi-annual newsletter highlighting a variety of activities in the field of mechanized silviculture across the country. Features include: list of coming events, reports on meetings, results of research or operational trials, and a list of recent reports relevant to the mechanization of silviculture. Another feature is a computerized equipment directory that provides information on individual pieces of equipment.

9. Publication: Silvicultural Site Preparation Productivity Study
Available from: B.C. Ministry of Forests and Lands
Silviculture Branch
1450 Government Street,
Victoria, B.C. V8W 3E7
Tel: 387-8911

This report provides productivity values for site preparation equipment used in British Columbia under a wide range of site conditions. The report is updated annually.

10. Video: Mechanical Site Preparation in North Central B.C. (1987)
Available from: B.C. Ministry of Forests and Lands
Silviculture Branch
1450 Government Street,
Victoria, B.C. V8W 3E7
Tel: 387-8909

This video presents a synopsis on the biological principles of mechanical site preparation, and reviews major types of site preparation equipment used in north central British Columbia.

APPENDIX 1. Contact individuals

The following individuals have experience with the equipment described in this guide and can be contacted for further details:

Leno (Model 77, Model 81)

Bill Chapman
Babine Forest Products
P.O. Box 4000
Burns Lake, B.C.
V0J 1E0
Tel: 692-7177

Guy Bailey
Ministry of Forests & Lands
Horsefly Forest District
Boswell St., Box 69
Horsefly, B.C.
V0L 1L0
Tel: 620-3417

Mounted on TD20 with V-blade
George Burns
Ministry of Forests & Lands
Kispiox Forest District
West Hwy. 62, Box 215
Hazelton, B.C.
V0J 1Y0
Tel: 842-6581

Bracke scarifier (2-row Model)

Charles von Hahn
Ministry of Forests & Lands
Vanderhoof Forest District
Spruce St., Box 190
Vanderhoof, B.C.
V0J 3A0
Tel: 567-6363

Heather Dawson
Ministry of Forests & Lands
P. G. West Forest District
1600 3rd Avenue
Prince George, B.C.
V2L 3G6
Tel: 565-6294

With herbicide attachment
Frank Gundersen
B.C. Forest Products
Box 310
Mackenzie, B.C.
V0J 2C0
Tel: 997-3271

Bracke mounder

Shelley Burns
The Pas Lumber
P.O. Box 879
Prince George, B.C.
V2L 4T8
Tel: 562-3361

Diane Renaud
Ministry of Forests & Lands
Ft. St. John Forest District
10716 - 100th Ave.
Fort St. John, B.C.
V1J 1Z3
Tel: 787-3323

Passive Disc Trenchers

TTS-35 disc trencher (modified for 3m specing)
Brian Walker
Fraser Lake Sawmills
Box 100
Fraser Lake, B.C.
V0J 2S0
Tel: 699-6235

CFE disc trencher (M&M)
Steve Knowles
Finlay Forest Industries
Box 250
Mackenzie, B.C.
V0J 2C0
Tel: 997-320

Neil Endacott
Ministry of Forests & Lands
Lakes Forest District
33 - 3rd Avenue, Box 269
Burns Lake, B.C.
V0J 1E0
Tel: 692-2235

Powered Disc Trenchers

Wadell
Richard Burkholder
Westar Timber Ltd.
Plateau Operations
Vanderhoof, B.C.
V0J 3A0
Tel: 567-4725

TTS Delta
Tan Calhoun
Ministry of Forests & Lands
33 - 3rd Avenue
Burns Lake, B.C.
V0J 1E0
Tel: 692-2227

Donaren 180D
(on John Deere 850 crawler)
Dave Greenly
Ministry of Forests & Lands
120 Mackenzie Blvd., Box 10
Mackenzie, B.C.
V0J 2C0
Tel: 997-3310

Beales or other standard brush blade

Dale Likes
Northwood Pulp and Timber Ltd.
Box 9000
Prince George, B.C.
V2L 4W2
Tel: 962-9611

Kelly Powell
Weldwood of Canada Ltd.
100 Mile House Operations
Box 97
100 Mile House, B.C.
V0K 2E0
Tel: 395-2285

Eden rake

Charles Von Hahn
Ministry of Forests & Lands
Vanderhoof Forest District
Spruce St., Box 190
Vanderhoof, B.C.
V0J 3A0
Tel: 567-6363

Allison Patch
Ministry of Forests & Lands
Lakes Forest District
33 - 3rd Ave, Box 269
Burns Lake, B.C.
V0J 1E0
Tel: 692-2232

FMC with 4- and 6-way brush blades

Dirk Trigg
Ministry of Forests & Lands
Horsefly Forest District
Boswell St., Box 69,
Horsefly, B.C.
V0L 1L0
Tel: 620-3417

V-plows: Beales type, Muirs type, West Fraser type

Ross Olsen
West Fraser Mills Ltd.
Box 6000
Quesnel, B.C.
V2J 3J5
Tel: 992-9244

Ivan Listar
Ministry of Forests & Lands
Morice Forest District
3429 - 10th St., Bag 2000
Houston, B.C.
V0J 1Z0
Tel: 845-6212

Mounted on D8 and D9 crawlers
Brian Walker
Fraser Lake Sawmills
Box 100
Fraser Lake, B.C.
V0J 1S0
Tel: 699-6235

C&H plow

SP 609
Steve Knowles
Finlay Forest Industries Ltd.
Box 250
MacKenzie, B.C.
V0J 2C0
Tel: 997-3201

Paul Sears
Balfour Forest Products Inc.
Netherlands Overseas Mills
Box 789, Station A
Prince George, B.C.
V2L 4T3
Tel: 561-2374

Marttini plow (Model KLM 240)

Keith Branter
Reforestation and Reclamation Branch
Alberta Forest Service
9920 - 108th St.
Edmonton, Alta.
T5K 2M4
Tel: (403) 427-8474

Otto Slavik
Balfour Forest Products Inc.
Netherlands Overseas Mills
Box 789, Station A
Prince George, B.C.
V2L 4T3
Tel: 561-2374

Ripper plow

Dave Landry
Peace Wood Products Ltd.
Box 29
Taylor, B.C.
V0C 2K0
Tel: 789-3327

Dave Menzies
Canadian Forest Products
R.R. #1, Site 13, Comp. 2
Fort St. John, B.C.
V0C 1J0
Tel: 788-2686

Modified C-S ripper plow
Daryl D. Amico
Blueridge Lumber Ltd.
Box 1079
Whitecourt, Alta.
T0E 2L0
Tel: (403) 648-3733

Anchor chain drag scarifier

Bill Chapman
Babine Forest Products Co.
P.O. Box 4000
Burns Lake, B.C.
V0J 1E0
Tel: 692-7177

Hank Krawczyk
Chetwynd Forest Ind.
Box 426
Chetwynd, B.C.
V0C 1J0
Tel: 788-2686

With 6.4-m delta V bar
Len McClinton
Ministry of Forests & Lands
McBride Forest District
300 Robson Sq., Box 40
McBride, B.C.
V0J 2E0
Tel: 569-2265

Sharkfin barrels

Michael Breisch
Northwood Pulp and
Timber Ltd.
Box 158
Houston, B.C.
V0J 1Z0
Tel: 845-2221

Hank Krawczyk
Chetwynd Forest Industries
Box 426
Chetwynd, B.C.
V0C 1J0
Tel: 788-2686

Karl Wagner
Ministry of Forests & Lands
Ft. St. James Forest District
Stones Bay Road, Box 100
Fort St. James, B.C.
V0J 1P0
Tel: 996-7131

Marden chopper

Lou Tromp
Ministry of Forests & Lands
Williams Lake Forest District
385 Barnard St.
Williams Lake, B.C.
V2G 1G2
Tel: 398-4335

Agricultural discs and plows

Cal Wilson
Ministry of Forests & Lands
Dawson Creek Forest District
9000 - 17th St.
Dawson Creek, B.C.
V1G 4A4
Tel: 782-8195

Double-discing
Keith Bramter
Reforestation and Reclamation Branch
Alberta Forest Service
9920 - 108th St.
Edmonton, Alta.
T5K 2M4
Tel: (403) 427-8474

Sinkkila HMF scarifier

Cal Wilson
Ministry of Forests & Lands
Dawson Creek Forest District
9000 - 17th St.
Dawson Creek, B.C.
V1G 4A4
Tel: 784-2350

Sinkkila HMF scarifier
(modified, 1987)
Brian Carnell
Canadian Forest Products
Box 749
Highlevel, Alberta
T0H 1Z0
Tel: (403) 926-3781

Cat 205 excavator

Bob Richards
Ministry of Forests & Lands
P. G. East Forest District
4055 - 15th Ave.
Prince George, B.C.
V2N 1A5
Tel: 562-4121

Guy Bailey
Ministry of Forests & Lands
Horsefly Forest District
Boswell St., Box 69
Horsefly, B.C.
V0L 1L0
Tel: 620-3327

John Deere 490
(for mounding)
John Casteel
Lakeland Mills Ltd.
Box 1358
(CNR Right-of-Way)
Prince George, B.C.
V2L 4V4
Tel: 564-6810

Madge Rotary Landbreaker

Diane Renaud
Ministry of Forests & Lands
Fort St. John Forest District
10716 - 100th Avenue
Fort St. John, B.C.
V1J 1Z3
Tel: 787-3323

Eden relief bedding plow

Delee Anderson
Ministry of Forests & Lands
Vanderhoof Forest District
Spruce Street, Box 190
Vanderhoof, B.C.
V0J 3A0
Tel: 567-6363

Brian Wesleyson
Ministry of Forests & Lands
Fort St. John Forest District
10716 - 100th Avenue
Fort St. John, B.C.
V1J 1Z3
Tel: 787-3326

CFE (Raumfix) slash rake

Jim Maxwell
Ministry of Forests & Lands
Silviculture Branch
1450 Government St.
Victoria, B.C.
V8W 3E7
Tel: 387-8911

Charles von Hahn
Ministry of Forests & Lands
Vanderhoof Forest District
Spruce St., Box 190
Vanderhoof, B.C.
V0J 3A0
Tel: 567-6363

Ministry D7/D8 mounder

Brian Wesleyson
Ministry of Forests & Lands
Fort St. John Forest District
10716 - 100th Ave.
Fort St. John, B.C.
V1J 1Z3
Tel: 787-3326

Lorne Bedford
Ministry of Forests & Lands
Silviculture Branch
1450 Government St.
Victoria, B.C.
V8W 3E7
Tel: 387-8909